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ERRATA FOR VOLUME VI

Plates III and IV legends, for Laestadia read Guignardia.
Page 225 footnote 3, for Uredinae read Uredineae.
Page 229 lines 6 and 10, for uredenial read uredinial.
Page 232 line 2, for suggests read suggest.
Page 237 line 13, for positively read positive.
Page 239 line 4 (from bottom) for Cronartim read Cronartium.
Page 261 line 1 of table, for perithecia read pycnidia.
Page 266, in legends for figures 10, 11, 15, 16, and 17, for perithecium read pycnidium.
Page 281, interchange legends for figures 2 and 3.
Page 285 footnote 8, omit. See Phytopath. **6**: 447.
Page 311 line 3, omit (Abstract).
Page 314 line 39, for 33–1 read 33: 1.
Page 316 line 10, for extract read Abstract.
Page 317 line 42, insert (Abstract.) after fungi.
Page 376 line 39, for 54 read 45.
Page 383 line 14, for waster read waste.
Page 417 line 15, omit 1 following June.
Page 418 line 10, for Sphæyonemella read Sphæronæmella.
Page 432 reference 14, for 44 read 4.

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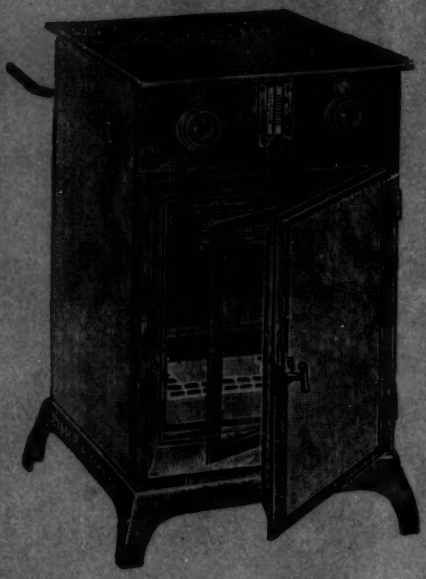

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VOLUME VI NUMBER 1

FEBRUARY, 1916

MORDECAI CUBITT COOKE

(1825–1914)

H. T. Güssow

With Portrait, Plate I

There is carved upon a certain tombstone in St. Mary's Islington Cemetery at East Finchley, England, the representation of a lowly and obscure plant. The image excites the curiosity of the visitor for it embodies a toadstool. Why, among all the beautiful and ornate members of the Vegetable Kingdom, should the choice fall on such an unattractive member?

Yet this little toadstool, linked with the name of the man resting beneath the tombstone, has a history, and with reverence the interested visitor will remember this. To us the toadstool is a Coprinus, or to be quite scientific, Coprinus micaceus of Fries—and its clump will remind us of the little woodcut which adorns the cover of the "Handbook of British Fungi" of which he, who lies beneath the tomb, was the author—Mordecai Cubitt Cooke, the veteran mycologist and pioneer of British Mycology.

Mordecai Cubitt Cooke's life affords several generations of botanists as well as the present, ample food for thought. His unique training, his phenomenal interest in the natural sciences, his zeal in imparting such interest to the young, his untiring pen and his retiring nature stand out prominently among the characteristics of this remarkable man.

He was born at Horning, Norfolk, England, on the 12th of July, 1825. His father Mordecai Cooke was a member of an old respected Norfolk family which in past times spelled their name Coke. Mordecai—an old semitic name—was a traditional one, which had been in the family for many generations. Mordecai Cooke, senior, was in early manhood connected with the manufacture of bombazine, once a thriving local industry. He married Mary, daughter of William Cubitt, a schoolmaster of the neighboring village of Neateshead. On his marriage he opened a village store,

which is now the Horning Post Office, and it was here that their eldest son Mordecai Cubitt Cooke was born in 1825.

At an early age he went to a local dame's school where he remained until 1834. From there he went to Ilford to continue his education under an uncle, the Rev. James Cubitt, a Baptist minister, who, being learned in classics and mathematics, afterwards became a tutor at the famous Spurgeon's College.

In 1838 young Cooke returned to Horning taking with him from his learned uncle a useful knowledge of ancient languages, algebra, and a love for observations and study of art and science. We then find him attending a local school at Neateshead.

In 1840 he was forced through circumstances to interest himself in the trade of a wholesale draper, to whom he was apprenticed, but this occupation proved heartily distasteful to a young fellow of his natural inclinations. In 1845 he again went back to London. Young Cooke was a romantic youth—in character like certain heroes portrayed by Ibsen, mayhap likest of all to Peer Gynt—impressionable, loving freedom and yearning for knowledge.

At the age of twenty-one he published a volume of verse (I am told of no particular merit) entitled *The Struggle of Freedom and other Poems.*

He interested himself greatly in poetry and literature generally and we find him lecturing and writing thereon; at that time, no doubt, augmenting by these means the meagre income which he earned in his capacity of copying clerk in a solicitor's office.

The next few years the young man spent in the search for some more congenial and permanent occupation. He made himself acquainted with the system of education of Pestalozzi, and for a brief period taught this method as a pupil teacher in an infant school, kept by an uncle and aunt of his, at Stockton-on-Tees.

He then was fortunate in securing an appointment as headmaster of the National Schools at Lambeth, where he remained during the years 1851–1860. He continued with fervour his botanical studies, gained a first class certificate in botany and founded the Society of Amateur Botanists. Here he became acquainted with Worthington G. Smith, another ardent lover of nature, and a botanist of no mean achievement. It is natural that this association led him to become more specially interested in the study of micro-fungi and fungous parasites. During this time he prepared a comprehensive account entitled *A Plain and Easy Account of British Fungi*, of which the fourth edition appeared in 1860.

No doubt, his famous little books for the young, small octavo shilling manuals by "Uncle Matt," evolved during this time too. Cooke loved children to his old age, and his simple language was certainly calculated

to endear his books to the children. From his *Down the Lane and Back in Search of Wild Flowers* his kindly interest in the young is apparent. Charming words are contained in the preface:

"Dear children, this book is for you. I have written it for you, to help you to learn a little more about the wild flowers than you know, and yet not to trouble you with any more hard words than I can help. You love flowers, and so do I, and the more you know of them the better you will love them. I have pointed out the way to Cissy, how she was to find out their little secrets, and what I have said to her I say also to you. If you will follow her to do as she did, you may learn, as she learned, that the most common weed has a story to tell which may be told to a child; that nothing to Him, who made it, is common or unclean; and that wayside weeds have their place to fill and their duty to do in the world if only—

> To comfort man, to whisper hope whene'er his faith is dim;
> For Who so careth for the flowers will much more care for him.

While in Lambeth he made the acquaintance of P. L. Simmonds, author of *Economic Products of the Vegetable Kingdom*, and in 1861 he was engaged by Dr. Forbes Watson of the India Office to catalogue raw vegetable products, and so forth, that were sent to England for exhibition purposes. On completion of this work he was appointed to a post as Botanical Assistant in the India Museum at Fife House, Whitehall, London. During the years from 1862–1868 he acted as Editor to *Science Gossip*.

About 1865 he became actively interested in fungi, no doubt greatly stimulated by Berkeley with whom he became intimately acquainted and later closely associated. Then follow in rapid succession—his energy as it were a pent up flood suddenly released—numerous works from the pen of this "inveterate" writer. *Our Reptiles; Manual of Structural Botany; A Fern Book for Everybody; Manual of Botanic Terms; Rust, Smut, Mildew and Mould.*

In 1872 he commenced *Grevillea*, first published monthly, later on quarterly. This journal of Cryptogamic Botany has a wide circulation and brought Cooke specimens of Fungi from all over the world, and the number of new genera and species described by him was immense. In consideration of his interest in American mycology some singular honours were conferred upon him. The University of St. Lawrence in 1870 gave him the honorary degree of Master of Arts; in 1873 Yale conferred the same honour; and in 1874 New York University made him an honorary LL.D. In 1877 the Linnean Society elected him an Associate, and Mycological Societies all over the world made him an honorary member. In going over this long list it is curious to find that no German Society appears to have likewise honoured Cooke.

In 1880 Cooke's career nearly came to an end; the India' Museum was discontinued, and the staff was placed on the pension list, or dismissed. However, in that year appeared the first part of what Cooke termed "the most ambitious work of his career"—a book, the likeness of which in its completeness was never produced in any other country—the *Illustrations of British Fungi*, a monumental work of eight volumes with 1200 plates, completed in 1891. No doubt, this work attracted Sir Joseph Hooker's attention, who asked for the transfer of Cooke's services to the Royal Botanic Gardens, Kew, where he filled the post of first Cryptogamic Assistant until 1893. In 1883 *The Myxomycetes of Great Britain* appeared, an appreciation of Rostafinsky's methods. In 1889 this spirit, roaming and revelling in the natural kingdoms, published his *Toilers in the Sea;* in 1892, *The Vegetable Wasps and Plant Worms;* in 1893, *Romance of Low Life Among the Plants;* in 1894, *Handbook of British Hepaticae*, and *Edible and Poisonous Mushrooms;* in 1895, *Introduction to the Study of Fungi, Talks About Wild Flowers, Botanical Wall Charts for Use in Schools;* in 1906, *Fungoid Pests of Cultivated Plants;* in 1908 *Catalogue and Field Book of British Basidiomycetes for Use of Collectors*, etc., etc., etc.

In 1902 the Royal Horticultural Society conferred on him the Victorian Medal of Honour (V.M.H.), and in 1903 the Linnean Society honoured him with their gold medal.

During his long life he collected and preserved many thousands of fungi and other plants. In 1898 Kew acquired his private collections of some 46,000 specimens. He estimated that he drew over 14,000 figures as illustrations for his various works.

It was during his later years that I became intimately acquainted with this indefatigable man. We met twice monthly at that useful and interesting Institution of the Royal Horticultural Society, its Scientific Committee, which he attended in all sorts of weathers. He was a modest, kind old gentleman with a pronounced sense of humour. Unfortunately during his later years he was unable to work owing to the failure of his eyesight. The vision of one eye became totally obscured by cataract and the other partially so. He resignedly accepted the expert's dictum, saying "I have left my eyes behind in my microscope."

In 1912 through "inadvertence" Cooke's obituary notice appeared. But he remonstrated that this account was exaggerated and premature.

His faculties and his sense of humour remained with him until the very end. On the 19th of October he had a severe heart attack, and passed away quietly and painlessly on the 12th of November, 1914. Thus ended the career of another of our respected and valued pioneers in mycology.

THE LEAF BLOTCH DISEASE OF HORSE-CHESTNUT[1]

V. B. Stewart

With Plates II, III and IV and One Figure in the Text

The leaf blotch disease is the most important malady affecting the horse-chestnut (*Aesculus hippocastanum*) and the common Ohio buckeye (*A. glabra*). The red buckeye (*A. parviflora*) is affected also by a similar disease. The leaf blotch is known in America and Europe, apparently occurring, to some extent at least, wherever the horse-chestnut or allied species are found. It is not observed so commonly in northern Europe as in the southern part.[2] In eastern United States where the horse-chestnut has a wide distribution, the disease is frequently observed and often a large percentage of the foliage on mature trees is affected. In nursery plantings leaf blotch is particularly destructive. Very often, by midsummer, the seedling beds are completely defoliated and the growth of the young trees is greatly retarded.

When the disease has become established in a block of young nursery trees it usually causes considerable damage each year. The affected trees develop more slowly and a longer period of time is required for them to attain a marketable size. Several plantings from seed have been observed which have made practically no increase in size for three consecutive seasons, due to the abundant infections each year. Premature defoliation not only checks the growth of the young trees but apparently the affected trees are less able to withstand the adverse conditions of the winter months; an injury and dying back of the twigs and branches has been known to occur on trees which were badly diseased the previous summer.

SYMPTOMS

The leaves and occasionally the petioles, are affected; the writer has also observed lesions on the immature fruits which were undoubtedly

[1] Acknowledgments—The writer is indebted to Dr. Donald Reddick and Dr. H. M. Fitzpatrick of Cornell University for many suggestions during the progress of the work. Certain material for study was kindly furnished by Prof. H. W. Anderson of Wabash College and by Miss Anna E. Jenkins of the United States Bureau of Plant Industry.

[2] Dr. Otto Appel of Germany and Dr. F. Kølpin Ravn of Denmark while visiting in the United States the past year, informed the writer that they had not observed the leaf blotch affecting the various species of Aesculus in their respective countries.

due to the leaf blotch disease, but this point was never definitely determined. The first indication of the disease on the foliage is a slight discoloration at the point of infection. As the lesion increases in size it becomes more or less irregular in outline and the newly invaded tissue appears water-soaked. Gradually the center of the lesion becomes dark red to brown in color, while the margin shows the yellowish discoloration blending into the green of the healthy tissue; and finally the discolored area becomes dried out and dead (Plate II). The spots may be small or of considerable size involving a large part of the leaf and causing the dead area to curl. Generally minute black specks may be seen sparsely scattered over the lesion and occasionally they appear before the tissue is completely dried out. Oftentimes they are crowded together in a definite area which may be slightly lighter in color than the remainder of the affected tissue. The lesions on the petioles appear in the form of small reddish brown spots which are usually somewhat longer than wide and extend up and down the petiole. The effects of the malady on the petioles is never very serious. The spots on the fruit are similar to those on the petioles; there is no decay of the fruit tissue.

The striking symptoms of the leaf blotch disease are the dark red- or brown-colored lesions which often involve large portions or even the entire leaf. When the disease is very prevalent, especially in nursery plantings, the foliage of the trees appears as if it had been burned over by fire.

ETIOLOGY

The leaf blotch disease on horse-chestnut is caused by a fungous pathogene. Various names have been applied to the fungus. This is due apparently to the lack of knowledge regarding the different stages in the life cycle of the organism and also to the occurrence of the organism on another species of the genus Aesculus.

The first description of an organism causing a leaf blotch disease on a species of Aesculus was by J. B. H. J. Desmazières[3] in 1847. He gave it the name *Phyllosticta Paviae* Desm. This description was based on the pycnidial stage of a fungus which he observed on the living foliage of *Pavia macrostachya* DC., now regarded as a synonym of *Aesculus parviflora* Walt. Later in 1883, Ellis and Everhart[4] described a fungus similar to *Phyllosticta Paviae*, as causing the leaf blotch of *Aesculus hip-*

[3] Desmazières, J. B. H. J. Quatorzieme Notice, Sur les Plantes Cryptogames Recemment Decouvertes en Fraoce. No. 48. Phyllosticta Paviae Desmaz. Ann. Sci. Nat. ser. 3, **8**: 32–33. 1847.

[4] Ellis, J. B. and Everhart, B. M. New species of fungi. Phyllosticta sphaeropsoidea. Bul. Torr. Bot. Club **10**: 97. 1883.

pocastanum and gave this species the name *Phyllosticta sphaeropsoidea* E. & E.

Morphologically this fungus is identical with the species described by Desmazières as occurring on *A. parviflora* and in their publication of the North American Phyllostictas,[5] Ellis and Everhart regard *P. sphaeropsoidea* as a synonym of *P. Paviae*. Since that time *Phyllosticta Paviae* has been considered usually as the fungus causing the leaf blotch of the three species *Aesculus parviflora*, *A. glabra* and *A. hippocastanum*. But from the results of inoculation experiments subsequently discussed the writer is obliged, for the present at least, to regard *P. Paviae* and *P. sphaeropsoidea* as two physiologically different organisms. Ascospores and also pycnospores from affected leaves of *A. hippocastanum* failed to infect the foliage of *A. parviflora*. Although several attempts in the cross inoculation work gave the same results in each case, the writer is not fully convinced that the two so-called species are different.

Saccardo[6] in 1879 observed a Phyllosticta-like fungus on the diseased foliage of *A. hippocastanum* and owing to the minuteness of the fruiting bodies he considered this form a new species giving it the name, *Phyllosticta aesculicola* Sacc. Later Ellis and Martin[7] described a similar fungus found on *A. glabra* and named it *Phyllosticta Aesculi* E. & M., but Ellis and Everhart list *P. Aesculi* as a synonym of *P. aesculicola*. Besides the above named species, *Phyllosticta aesculina*, Sacc., has been described by Saccardo[8] as occurring on *A. hippocastanum*. In his description of *P. aesculina*, Saccardo states that this species differs particularly from *P. aesculicola* in the double size of the spores.

The polymorphic nature of the leaf blotch fungus, especially with respect to the spermagonial stage, has been responsible, apparently, for the numerous species of Phyllosticta mentioned above. The writer has seen no reference in literature to the occurrence of spermagonia in the life cycle of this fungus. Without question the fruiting bodies which led Saccardo to establish the species *P. aesculicola* and also *P. aesculina*, are the spermagonial stage of the leaf blotch fungus. The writer has observed spermagonia on leaves of both *A. hippocastanum* and *A. glabra*, which with relation to size, shape and general characters, are in accordance with

[5] Ellis, J. B. and Everhart, B. M. Phyllosticta Paviae Desm. The North American Phyllostictas, p. 41. 1900.

[6] Saccardo, P. A. Fungi Veneti. Phyllosticta aesculicola Sacc. Mich. **1**: 134. 1879.

[7] Ellis, J. B. and Martin, Geo. New Fungi. Phyllosticta Aesculi E. & M. Jour. Myc. **2**: 130. 1886.

[8] Saccardo, P. A. Fungi Gallici ser. 6, no. 2261. Phyllosticta aesculina Sacc. Description in Syl. Fung. **3**: 3–4. 1884.

Saccardo's descriptions of *P. aesculicola* and *P. aesculina*. Specimens have been examined of the same collection from which type material of *P. Aesculi*, a synonym of *P. aesculicola*, was taken and the fruiting bodies present, on the basis of which the species was established, are similar to the spermagonia found on leaves affected by the leaf blotch fungus.

As previously stated, Saccardo considered *P. aesculicola* and *P. aesculina*, as two distinct species on the basis of spore measurements. *P. aesculicola* is described as having minute, hyaline, oblong spores, measuring 3 to 4 by 0.75μ, while the spores of *P. aesculina* are oblong and hyaline, and measure 9 by 3μ. A large number of measurements of both spermagonia and spermatia on leaves of *A. hippocastanum* and also on *A. glabra*, have been made by the writer. These measurements show a wide variation in the size of the spermatia, ranging from 3 to 9 by 0.75 to 3μ. Frequently the spermatia in the same spermagonium are more or less uniform being either of the large or small type. This was no doubt true in the case of the material on the basis of which the new species were established. On the other hand, both large and small spermatia have been observed in the same spermagonium. Furthermore, both large and small spermatia have been found intermingled with pycnospores of the average size in the same fruiting body.[9]

The spermagonia-like bodies are always found associated with other stages in the life cycle of the leaf blotch fungus. They are similar to a stage regarded as spermagonia in the life cycle of other closely related species of fungi, particularly so of *Guignardia Bidwellii* (Ellis) Viala & Ravaz. The leaf blotch disease of horse-chestnut appears early in the season and only pycnidia with large spores (10 to 16μ by 6.5 to 10μ) are present in the lesions at that time. The spermagonia with minute hyaline spores appear along with the pycnidia and incipient perithecia on leaves infected after the first of August. They have not been observed previous to this time. A spermagonium frequently develops immediately next to and in the same stroma with a pycnidium or perithecium, the two being separated only by a thin membranous wall. This condition would be somewhat unusual if the two fruiting bodies were of different organisms. Also it is not a common occurrence to find spores of two distinct fungi in the same fruiting body as is the case where pycnospores are intermingled with spermatia. All attempts to germinate the spermatia have failed.

On the basis of these facts there seems to be but little doubt that the minute-spore forms are spermagonia of the leaf blotch fungus and not

[9] D. Reddick states (New York (Cornell) Agr. Exp. Sta. Bul. 293:328. 1911) that in case of *Guignardia Bidwellii* it is very common to find pycnospores intermingled with the spermatia in the same fruiting body.

fruiting bodies of different species. It is suggested, therefore, that *P. aesculina* and *P. aesculicola* (*P. Aesculi*) be reduced to synonomy.

The sexual stage of *Phyllosticta Paviae* on *Aesculus parviflora* has never been observed, although in 1887 Brunand[10] described a minute spore form, *Phyllosticta paviaecola* Brun., as occurring on *A. parviflora*. This form is similar to *P. aesculina* and judging from the different forms studied on affected leaves of *A. hippocastanum* and *A. glabra*, the fruiting bodies of *P. paviaecola* are simply the spermagonial stage of *Phyllosticta Paviae*. It is suggested, therefore, that *P. paviaecola* also be reduced to synonomy.

The ascogenous stage of the leaf blotch fungus was described by Peck[11] from material collected on the dead leaf petioles of *Aesculus hippocastanum*. Peck named the fungus *Laestadia Aesculi* but did not associate it with the pycnidial stage. In the month of May, 1914, the writer found perithecia on diseased horse-chestnut leaves which had been exposed to the weather throughout the winter months. These perithecia were similar to those described by Peck and inoculation experiments proved them to be the perfect stage of the leaf blotch fungus.

In considering the generic name of the fungus, the use of Laestadia as the name of a group of fungi is not permissible owing to the fact that previous to this time, a composite genus of Kunth[12] was given the name Laestadia. Moreover, considerable difficulty arises in placing this fungus in the proper genus on account of the somewhat imperfect classification of the Mycosphaerellae. The fungus fits well with the character of that group of Mycosphaerellae under which the genus Guignardia is included; the perithecia are single, paraphyses absent and the ascospores are one-celled. On the other hand, there is some doubt concerning the validity of the generic name Guignardia. This was pointed out by Reddick[13] in connection with the etiology of *Guignardia Bidwellii* (Ellis) Viala & Ravaz. However, with our present knowledge of the very large and imperfectly understood group of Mycosphaerellae, it appears impossible to determine the validity of the name Guignardia. The writer therefore proposes tentatively at least, the substitution of the name Guignardia for Laestadia, giving **Guignardia Aesculi** (Pk.) nov. comb. as the correct name of the leaf blotch fungus of horse-chestnut.

[10] Brunaud, Paul. Champigons a ajouter a la flore Mycologique des environs de Saintes. Phyllosticta paviaecola Brun. Bul. Soc. Bot. de France, ser. **34**: 430. 1887.

[11] Peck, Chas. H. Plants not before reported. Laestadia Aesculi Rept. New York State Botanist **39**: 51. 1885.

[12] Kunth. Lessing's Synopsis generum Compositarum, p. 203. 1832.

[13] Reddick, D. The black rot disease of grapes. New York (Cornell) Agr. Exp. Sta. Bul 293: 289–364. 1911.

DEVELOPMENT OF PYCNIDIA

A few days after the leaf blotch lesions appear on the foliage, numerous pycnidia may be seen somewhat sparsely scattered over the upper surface of the affected area and they also have been observed occasionally on the under side of the leaf. Usually they appear in the older dried out part of the lesion, but frequently are seen nearer the periphery in tissue which is not completely discolored and still contains some chlorophyl. The pycnidia measure from 90 to 175 μ in diameter and have a tendency to be globose in shape. There is a well developed ostiole (Plate III, figs. 3 and 4).

The development of the pycnidium is comparatively rapid. Fixed material from lesions showing the first signs of fruiting bodies gave pycnidia in several stages of development. In microtome sections, stained with iron alum haematoxylin, deeply stained hyphal threads may be noticed in the leaf tissue. The first indications of the pycnidial development is the interweaving of the mycelial hyphae which later anastomose forming a gnarl at some point between two palisade cells of the leaf tissue (Plate III, fig. 1). With increased growth of the fungous cells the adjoining host cells are forced apart and may be even entirely separated with the gnarl extending into the spongy parenchyma. The mycelial threads on the outside of the gnarl anastomose to form a pseudoparenchymatous tissue. But the greatest activities are apparently on the interior and by increased growth from the center the newly formed wall of the pycnidium is pushed out in all directions. At this time the pycnidium becomes noticeable externally by the epidermal cells being slightly pushed up and the cuticle broken. Cross sections of pycnidia in this stage of development show the mycelial hyphae to be less interwoven at the center with a tendency toward more or less radial arrangement as basal cells extending toward the center (Plate III, fig. 2). Soon the basal cells become more definite owing to their increase in length along with the growth of the pycnidium which rapidly attains the normal size. As the hyphal or basal cells reach the center the tips become swollen and more or less subclavate in shape. A constriction soon appears at a point just back of the sub-clavate tip (Plate III, fig. 5) which is finally cut off resulting in the formation of a pycnospore. With the production of large quantities of pycnospores in the pycnidium, space is provided for them by the disappearance of certain of the thin-walled cells on the interior and also by the pressure outward, which tends to push back the thick-walled pseudoparenchyma. In this way a greater cavity is produced within the pycnidium for the newly formed spores (Plate III, fig. 4). With the disappearance of the thin-walled cells on the interior there is

also the formation of the ostiole. The writer was unable to determine definitely the method of development of the ostiole in the pycnidium, however, this point was more thoroughly studied in connection with the development of the perithecium subsequently discussed.

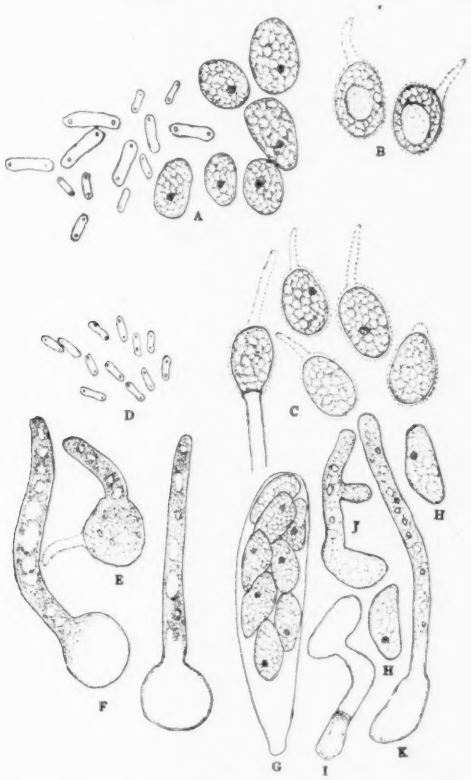

FIG. 1. Various spore forms of Guignardia Aesculi. *A*, Spermatia and pycnospores from the same fruiting body; *B*, Pycnospores with large guttulae; *C*, Pycnospores showing the appendages; *D*, Small-sized spermatia; *E*, Germinating pycnospore with appendage still attached; *F*, Pycnospores, forty-eight hours after germination; *G*, Ascus containing eight spores; *H*, Ascospores; *I*, Germinated ascospore showing formation of appressorium; *J* and *K*, Ascospores forty-eight hours after germination.

As the pycnospores are produced they are enveloped in a gelatinous substance which holds them apart. With the presence of moisture the gelatinous substance swells and the spores are discharged from the pycnidium through the ostiole. Held together by the gelatinous substance the spores often may be seen extruding from the ostiole as a white coil two or three millimeters in length.

There is considerable variation in the shape of the young pycnospores while in the pycnidium but when discharged and the pressure from all sides becomes more equal they are usually more or less ovoid. Oftentimes however, they are globose or oblong (fig. 1, a). The spores have one and frequently two nuclei and measure from 10 to 16 μ in length by 6.5 to 10 μ in diameter. They are hyaline with a granular content and may be one to two guttulate. Occasionally one large guttula is present as seen in figure 1, *b*. At the apex of the pycnospore there is present a very hyaline appendage which is generally slightly curved (fig. 1, *b* and *c*). The appendage appears to be an extension of the cell wall but is slightly granular and varies in length from one-third to somewhat longer than the pycnospore.

Considerable difficulty has been experienced in obtaining a high percentage of germination of the pycnospores although material from various sources was used. Usually, however, after twenty-four hours, spores in tap water will show the development of a small germ tube (fig. 1, *e*) which increases somewhat throughout the next twenty-four hours. The writer has seldom observed germ tubes of much greater length than those shown in figure 1, *f*. It is presumed that artificial conditions are not conducive to the production of germ tubes of any great length.

SPERMAGONIA

The spermagonia (Plate IV, fig. 10), have never been found previous to the month of August and they are less abundant as compared with the number of pycnidia. Usually they are most common after the first of September. At this time the spermagonia are more noticeable, especially on account of the fact that a large percentage of the pycnidia are void of spores. Under such conditions one might readily assume the spermagonia and pycnidia to be fruiting bodies of two different organisms. Of the several species of Phyllosticta described on Aesculus on the basis of this minute spore form, September has been, in each case, the date of collection of the type material.

The general scarcity of spermagonia in affected leaves has not permitted a thorough study of the development of these fruiting bodies. However, the few stages which have been observed indicate that the development is similar to that of the pycnidia. In several cases, as previously stated, the spermagonium has been found developing in the same stroma with a pycnidium or incipient perithecium (Plate IV, fig. 13), the two bodies separated only by a thin membranous wall. There is a wide variation in the size of the spermagonia which measure from 40 to 110 μ in diameter. They occur both on the upper and lower side of the leaf.

Within the spermagonium are developed large quantities of spermatia which are abstricted from the tips of basal cells or conidiophores and extruded through a well-developed ostiole (Plate IV, fig. 10). The basal cells of the spermagonia are much longer and not so blunt as those in the pycnidia. Frequently where a pycnidium and spermagonium develop in the same stroma, the membranous wall may be broken and pycnospores are found intermingled with spermatia. On the other hand, in some cases the two kinds of spores may be found in a single fruiting body which apparently has no connection with another.

The mature spermatium is oblong, hyaline and usually very minute, however, a wide variation in size has frequently been noticed. Spermatia from the same fruiting body intermingled with pycnospores show a variation in measurement from 3 to 9 μ in length by 0.75 to 3 μ in diameter (fig. 1, *a*). When seen in a liquid mount the spermatia appear to be somewhat enlarged at the ends, that is, dumb-bell shaped (fig. 1, *d*). This is due to the dense refractive protoplasmic content at these points. An effort has been made to germinate the spermatia both in tap and rain water but all attempts proved futile.

DEVELOPMENT OF PERITHECIA

Diseased horse-chestnut leaves collected September 10, 1914, showed numerous pycnidia-like fruiting bodies scattered over the affected area. On examination with the microscope a few of these were found to contain pycnospores but in most cases no spores had developed and the interior was filled with large pseudoparenchymatous cells which contained a white granular substance. These observations suggested a similarity between the leaf blotch fungus of horse-chestnut and *Guignardia Bidwellii* (Ellis) Viala & Ravaz., which causes the black rot of grapes. Further studies showed the pycnidia-like fruiting bodies to be incipient perithecia which Reddick[14] has designated as pycnosclerotia (Plate IV, figs. 11, 12, 13).

Soon after the middle of August following the appearance of the spermagonia, the incipient perithecia are found in the affected leaves. These are produced almost exclusively at this time instead of pycnidia, although a few pycnidia, bearing pycnospores, usually are present also. The development of the perithecium is similar to that of the pycnidium except that no basal cells are produced, the whole interior being filled with pseudoparenchyma of thin-walled cells. Sections of the young perithecium stained with iron-haematoxylin and counter-stained with Congo

[14] Reddick, D. The black rot disease of grapes. New York (Cornell) Agr. Exp. Sta. Bul. 293: 289-364. 1911.

red, show the dark, thick cells of the outer wall, with the reddish tinted thin-walled cells on the interior, some of which, near the center retain the haematoxylin stain more tenaciously (Plate IV, figs. 11 and 12). In the upper portion of the perithecium which protrudes slightly above the epidermis of the leaf, there is a wedge of tissue, cellular in appearance, which extends from the outside through the outer wall (Plate IV, fig. 11). Apparently this wedge is of the same origin as that which forms the thick pseudoparenchymatous tissue of the outer wall and differs from this tissue only in being thinner walled. The cell-like cavities are practically void of contents and the walls stain deep blue in contrast to the tissue on the interior of the perithecium in which the red stain predominates. In some cases the wedge of tissue is seen to protrude somewhat beyond the outer wall of the fruiting body (Plate III, fig. 6). After the formation of the perithecium to this point there is practically no further development until late winter.

Undoubtedly the weather conditions exert a considerable influence as to the time further activities are apparent in the perithecium, but material exposed to the weather throughout the winter months shows some development in late February and March, particularly with respect to the ostiole. Some of the cavities in the outer portion of the wedge appear to be breaking down and the tissue in this region is somewhat disorganized (Plate IV, fig. 12). With further development of the perithecium the disintegration of this tissue continues from the outside inwardly. The extent of disorganization is often sharply delimited as seen in Plate IV, figure 13. The lower portion of a layer of tissue is still intact and forms a definite line across the opening in the incipient perithecium. Finally the wedge disappears entirely leaving an opening through the outer wall; the complete disappearance of the wedge, however, may not occur until the asci are almost mature (Plate III, fig. 7). The complete formation of the ostiole results in the disappearance of the tissue on the interior which nourishes the ascogenous cells, subsequently discussed.

When activity begins in the formation of the ostiole some of the deeply staining cells in the center of the perithecium begin to elongate and push upward. These are the ascogenous cells (Plate IV, fig. 14), which number sixty or more in each perithecium. The development of all the ascogenous cells is not simultaneous and at first only a few may begin to elongate. Gradually as the season advances more of the cells become active and with their development there is a disappearance of the surrounding thin-walled cells which apparently serve as nourishing tissue for the ascogenous cells. After a considerable elongation a single well-defined nucleus appears near the center of each cell (Plate IV, fig. 15). The cell soon becomes more obtuse at the apex and with further develop-

ment it assumes the shape of the mature ascus (Plate IV, fig. 16). Up to this point the development is somewhat gradual depending upon the conditions; material examined March 10, 1915, showed the ascogenous cells about one-half to two-thirds the size of the mature ascus, but owing to the sudden fall in temperature accompanied by snow fall there was no further development when specimens from the same material were examined three weeks later. On the other hand, the transition from the uninucleate stage to the formation of the ascospores is very rapid.

It has been difficult to obtain intermediate stages. All of the material examined shows either the single nucleus in the ascus or the eight uninucleate ascospores more or less definitely outlined (Plate III, fig. 8). The transition from the uninucleate condition is evidently dependent upon weather conditions in the spring which are conducive to the maturation of the asci.

The mature ascus is subclavate in shape and the eight ascospores are somewhat crowded together toward the apex (fig. 1, *g*). There is considerable variation in the size of the asci, depending upon the conditions under which they are examined. In a dry mount the ascus measures 54 to 70 by 15 to 17 μ, but asci mounted in water have been observed which measured 98 μ in length. The significance of moisture is appreciated more in considering the discharge of the ascospores from the perithecium.

Frequently, when perithecia are mounted in water, asci may be seen protruding through the ostiole. The elongation of the ascus is due to the absorption of water and the subsequent gelatinization of the ascus wall which becomes almost invisible. With the protrusion of the ascus the ascospores are crowded together near the apex. Soon a slight movement is manifest by the distal spore which forces its way through the apex of the ascus and is violently ejected. There is no evidence of a pore by means of which the spores could pass out of the ascus. They apparently are forced through the gelatinized wall. With the ejection of the first spore the process continues rapidly and within a period of ten to thirty minutes, the ascus may be emptied of spores. The discharge of the spores is apparently in accordance with conditions favorable for infections of the newly developed foliage on the host plant in the spring.

The ascospores (fig. 1, *h*) are subelliptical, uninucleate, and have a granular content. They vary in size from 12 to 18 by 7 to 9 μ. Considerable difficulty has been experienced in obtaining germination of the ascospores. Various methods have been used but the percentage of germination is relatively low. In figure 1, *j* and *k*, is shown germinating ascospores after forty-eight hours; germ tubes of a greater length have never been observed. Frequently appressoria (fig. 1, *i*) are formed when the spores are allowed to germinate on the surface of agar.

MYCELIUM IN THE TISSUE

The incubation period of ascospore inoculations is from ten to twenty days. After the infection appears the development of the water-soaked lesion is rapid. The mycelium in newly invaded tissue is hyaline, septate, somewhat granular and irregular, and it varies from 2 to 4.5 μ in diameter. It is both inter- and intracellular and branches profusely, but no haustoria have been found. The mycelial hyphae which ramify the tissue attacked, cause a necrosis of the cells. In Plate IV, figure 9 is shown a cross section of a leaf through the edge of a leaf blotch lesion. A sharp line of demarcation separates the healthy tissue from the diseased area. The cells of the mesophyll and of the palisade layer are shrunken and dried out so that at some points they are hardly recognizable as cells. The affected tissue, however, remains intact. There is no enzymic action on the middle lamellae, causing the cells to separate and the tissue to disintegrate.

CULTURAL STUDIES

Petri dishes containing a thin layer of agar may be inverted over moist bits of leaves bearing perithecia and when the spores are ejected from the asci they lodge on the agar surface above. The greatest number of ascospores are obtained when the bits of leaf are not more than one-half centimeter from the agar, but a few spores may reach the agar when it is about one centimeter from the leaf. Very few of the spores which were secured in this way have germinated and in no case has a mycelium been developed. By examining the plates of agar from the under side with a low magnifying microscope, an occasional germ tube may be seen and frequently after a slight germination an appressorium is formed. No further development has been observed although various kinds of agar were used including nutrient agar and agars containing decoctions of horse-chestnut, oats and potatoes. A pure culture from an ascospore was finally obtained by transferring a single germinated spore on a small piece of agar to a test tube containing a sterilized horse-chestnut leaf petiole.

The fungus which developed from the single ascospore on the leaf petiole was similar to that isolated from an infected horse-chestnut leaf that contained mature pycnidia of the fungus. Later when transfers were made from the culture on the sterilized leaf petiole, to test tubes containing either sterile bean pods or oat agar, the fungus made a very satisfactory growth. Potato agar did not prove a favorable medium for the fungus. The cultures from the ascospore and also from the diseased leaf, consisted of a black mycelial growth with the development of small sclerotia-like bodies which were about one millimeter in diameter. Although the fungus

from the two sources was cultured for a period of twelve months on various media, no fruiting bodies ever developed. Apparently the media and conditions were not suitable for the formation of fruiting bodies.

INOCULATION EXPERIMENTS

On May 10, 1914, ascospores were obtained by inverting plates of agar over bits of horse-chestnut leaf bearing mature perithecia. Under sterile conditions the numerous spores were scraped from the agar surface and transferred to the leaves of two horse-chestnut seedlings growing in the greenhouse. The two inoculated seedlings and two others for check plants were then placed in a large moist chamber for four days. After twelve days numerous lesions were apparent on the leaves of the seedlings which had been inoculated. The affected areas soon appeared discolored and water-soaked and later turned reddish brown, characteristic of the infections of the leaf blotch disease. On June 2, pycnidia bearing mature pycnospores had developed on the lesions. The pycnidia and pycnospores appeared to be identical with the Phyllosticta stage of the leaf blotch fungus. The two check plants remained healthy.

Practically the same results were obtained when this experiment was repeated in the spring of 1915.

CROSS INOCULATIONS

On May 27, 1915, ascospores from perithecia in leaves of *Aesculus glabra* were ejected under sterile conditions onto inverted plates of agar. Ascospores were also obtained by crushing perithecia from leaves of *A. glabra* in a drop of sterile water. The two quantities of spores were kept separate and used for inoculating seedlings in the greenhouse. One *Aesculus glabra* seedling and two *A. hippocastanum* seedlings were inoculated with the spores crushed from the perithecia. Two *A. glabra* and two *A. hippocastanum* seedlings were inoculated with the spores which were scraped from the plates of agar. One *A. glabra* and two *A. hippocastanum* seedlings were used as checks. All the seedlings were placed in a moist chamber for five days.

On June 6, several of the leaves showed signs of infection and four days later lesions of the leaf blotch disease were apparent on all of the inoculated seedlings. Young pycnidia were present July 15 and when again examined June 24 mature pycnospores were found. The check plants remained healthy.

Infections have also been obtained by inoculating *A. glabra* seedlings with ascospores from *A. hippocastanum* leaves. This indicates that both of the species of Aesculus are attacked by the same organism.

Owing to the scarcity of the species *Aesculus parviflora*, it was difficult to find material suitable for inoculation work. Only a single mature bush of this species was available.

On May 4, 1915, ascospores crushed from perithecia on *A. hippocastanum* leaves were placed on moistened leaves on three shoots of the *Aesculus parviflora* bush. The shoots were then covered with large test tubes and the opening at the bottom of the tubes plugged with moist cotton. Two shoots were covered with the test tubes for checks. At the same time two *A. hippocastanum* seedlings in the greenhouse were inoculated with ascospores from the same source. The inoculated seedlings and one check plant were then placed in a large moist chamber for three days. The test tubes were removed from the *A. parviflora* shoots after three and one-half days. On May 21 several lesions were apparent on the inoculated horse-chestnut seedlings, but no infections ever appeared on the *Aesculus parviflora* leaves. All the checks remained healthy.

On July 31, 1915, pycnospores from infected *A. hippocastanum* leaves were placed on the moist leaves of two *A. parviflora* shoots. The inoculated shoots were then covered with large test tubes plugged at the bottom with moist cotton. One other shoot was covered for a check. Two *A. hippocastanum* seedlings, growing outside, were inoculated also with pycnospores from the same leaves. The two seedlings and one check plant were covered with lamp chimneys plugged at the top with cotton. Five days later all of the lamp chimneys and large test tubes were removed. When examined August 15, both of the inoculated *A. hippocastanum* seedlings were infected and young fruiting bodies were apparent on August 21. None of the inoculated *A. parviflora* shoots became diseased and all checks remained healthy.

One other attempt was made to inoculate the leaves of *A. parviflora* with pycnospores from diseased foliage of *A. hippocastanum* but no infections were produced. The cause of the failure of these cross inoculations was not determined, but several possibilities suggest themselves: Possibly the two fungi on *A. parviflora* and *A. hippocastanum* are specifically different; or there may be different strains of the same fungus which are limited in their attacks on the various host plants; the question of technique is also of importance. The method of inoculation was practically the same, except that for the *A. parviflora* shoots it was almost necessary to use the large test tubes for moist chambers, their length of about thirty-two centimeters being a big advantage in covering a sufficient amount of the foliage. In considering these points along with the results obtained the experiments appear to be worthy of repetition.

CONTROL

Dusting with sulfur or spraying with either lime-sulfur solution or bordeaux mixture are effective in controlling the leaf blotch disease. Dusting with sulfur is preferable as the dense foliage, especially of horse-chestnut trees, can be more thoroughly covered.

In the nursery, especially the small seedlings, the greatest damage is caused by the ascospore infection early in the spring, before the foliage is fully developed. Leaves which are near the ground suffer more severely at this time than the foliage of mature trees. The greatest injury to large trees is caused by the secondary infections from pycnospores during June and July. For nursery stock, therefore, the first application should be made to prevent the ascospore infections and large trees should be treated soon after the foliage is fully developed. There is practically no secondary growth and relatively little new foliage is developed during the summer on the horse-chestnut trees. For this reason, about three or four applications of the dust mixture at intervals of three to four weeks should be sufficient to control the disease.

A dust mixture of ninety parts finely ground sulfur and ten parts powdered arsenate of lead has proved very effective. The dust is preferable also to the lime-sulfur solution, from the fact that in attempting to thoroughly cover the dense foliage with the spraying solution, the trees often are drenched causing injury by burning. However, lime-sulfur solution, one part to fifty gallons of water is effective in controlling the fungus on well sprayed foliage.

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STEWART: LEAF BLOTCH OF HORSE-CHESTNUT

Explanation of Plate III

Fig. 1. Early stage in development of pycnidium of Guignardia Aesculi, showing gnarl of mycelium in leaf tissue. Magnified 240 times.

Fig. 2. Young pycnidium, showing radiating hyphae. Magnified 240 times.

Fig. 3. Pycnidium with mature pycnospores. Magnified 260 times.

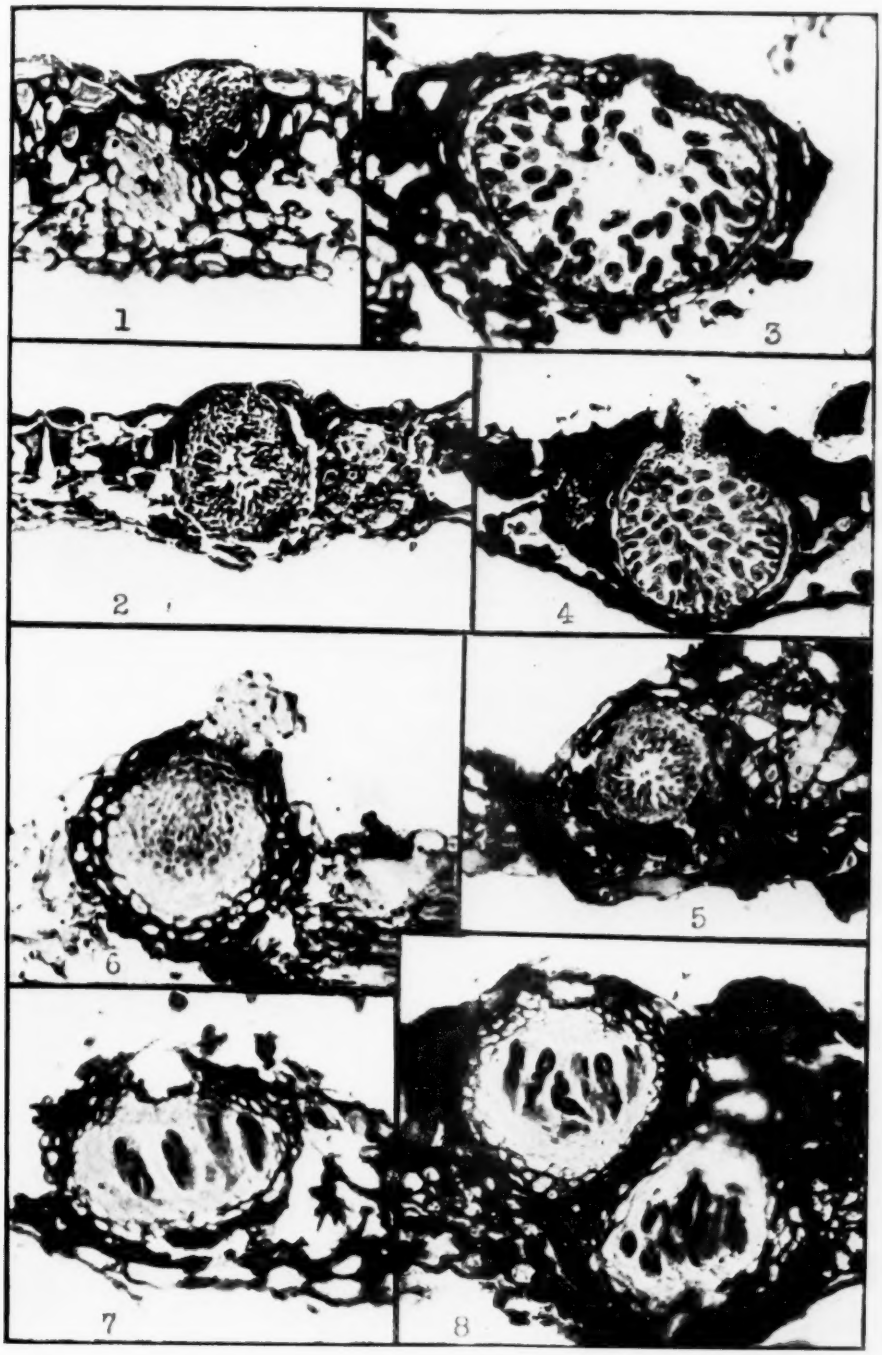
Fig. 4. Pycnidium showing ostiole and also subclavate conidiophores. Magnified 240 times.

Fig. 5. Young pycnidium slightly more advanced than in figure 2, showing the development of the pycnospores at the tips of the radiating hyphae or conidiophores. Magnified 240 times.

Fig. 6. Incipient perithecium showing early stage in development of ostiole with wedge of cells protruding beyond the outer wall. Magnified 240 times.

Fig. 7. Perithecium with asci, also showing the opening through the outer wall for the ostiole. Magnified 240 times.

Fig. 8. Perithecia developing on opposite sides of the leaf. In the upper perithecium are mature asci. Magnified 240 times.



STEWART: LAESTADIA AESCULI

Explanation of Plate IV

Fig. 9. Section of horse-chestnut leaf showing healthy and diseased tissue. Magnified 240 times.

Fig. 10. Spermagonium of Guignardia Aesculi. Some of the spermatia have been extruded through the ostiole to the outside. Magnified 240 times.

Fig. 11. Incipient perithecium with deep staining cells in the center. Material fixed September 15, 1914. Magnified 240 times.

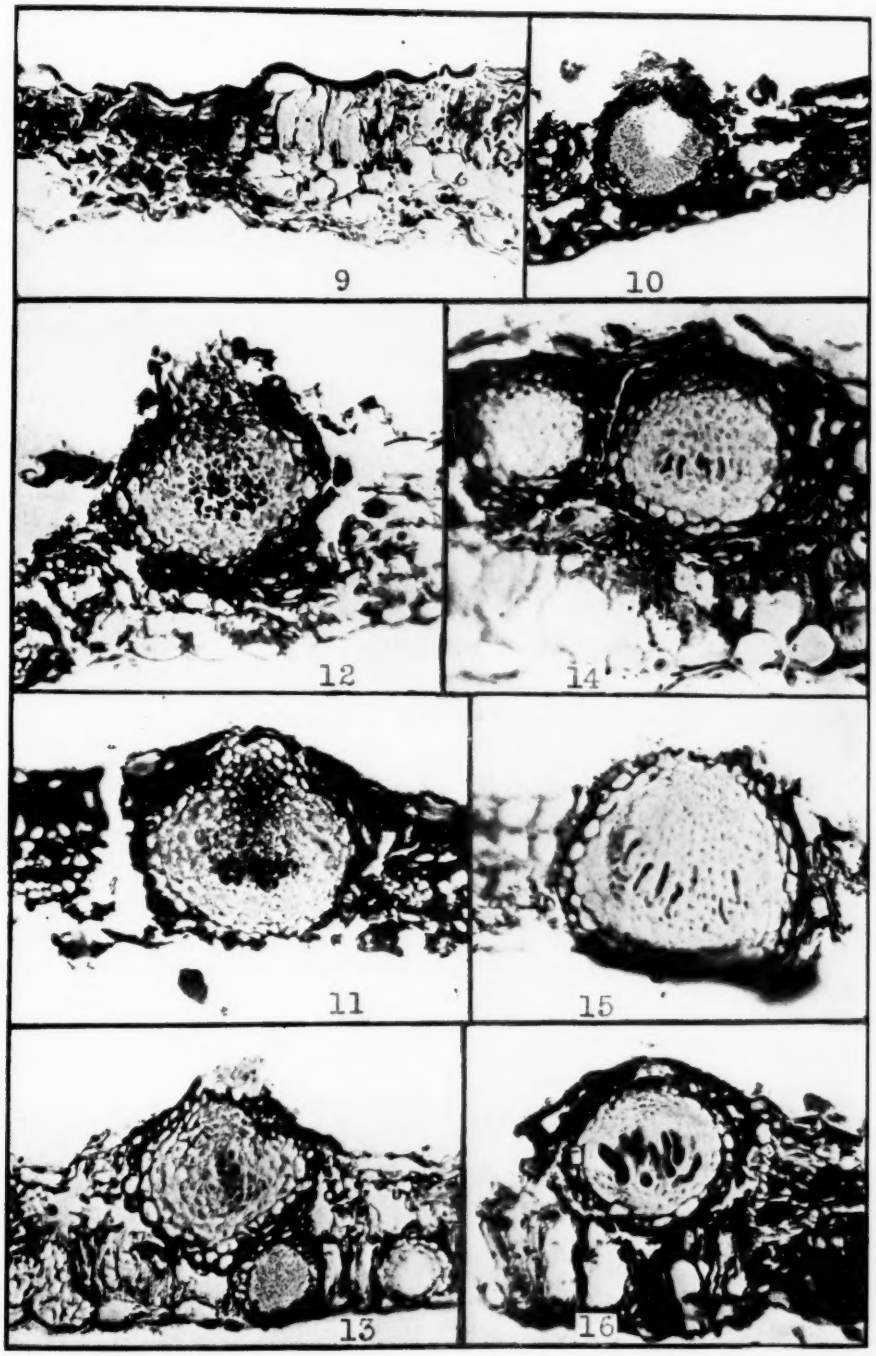
Fig. 12. Young perithecium showing disorganization of the wedge of tissue in the formation of the ostiole. Material fixed February 3, 1915. Magnified 240 times.

Fig. 13. Young perithecium showing formation of the ostiole also with spermagonium in the same stroma as the perithecium. Material fixed February 18, 1915. Magnified 240 times.

Fig. 14. Perithecia, one with very young asci. Material fixed February 26, 1915. Magnified 240 times.

Fig. 15. Perithecium with asci slightly more advanced than those in figure 14. Some of the asci show a single nucleus. Material fixed March 20, 1915. Magnified 240 times.

Fig. 16. Perithecium with immature asci. Magnified 240 times.



STEWART: LAESTADIA AESCULI

OBSERVATIONS ON THE PATHOLOGICAL MORPHOLOGY OF STINKING SMUT OF WHEAT

MORTIER F. BARRUS

WITH THREE FIGURES IN THE TEXT

The writer has had an opportunity to watch the development of plants in experimental plats relating to the control of stinking smut of wheat caused by *Tilletia foetens*. Soon after the plants were headed out a determination of the percentage of affected plants was made and in doing this some peculiar characters of the smutted plants were brought forcibly to the writer's attention. There is so much difference in size and color of heads, and in the flowering parts that there can be no mistaking affected plants for healthy ones. The writer never having observed many of these differences nor having had them called to his attention by anything he had read, was led to make and to present here the following observations.

A careful study was undertaken at the time the plants were in bloom (June 14) and continued until harvest time but for the stages preceding blossoming it was possible to secure material from plants at the margins of the plats and from those growing in the shade in which places the development had been delayed. The symptoms of the various parts as they appeared at different stages in the development of the heads are here recorded.

The seed wheat used for the experiment was a white variety of *Triticum vulgare* similar to Dawson's Golden Chaff and contained 40 per cent of smutted kernels. The plots were heavily seeded on stony ground and were not fertilized. As a result the wheat produced in most cases but a single fruiting culm to the seed and the heads probably are shorter than they would have been under more favorable conditions for growth.

CONDITION PRIOR TO EMERGENCE OF HEAD

Observations were made at a period of about three days prior to the emergence of the head from the upper leaf sheath. At this time no difference between healthy and diseased plants can be observed, so far as the appearance of the heads or the florets are concerned. An examination of the flowering parts, however, reveals striking differences. The pistil of the diseased flower is much larger than a healthy pistil and the

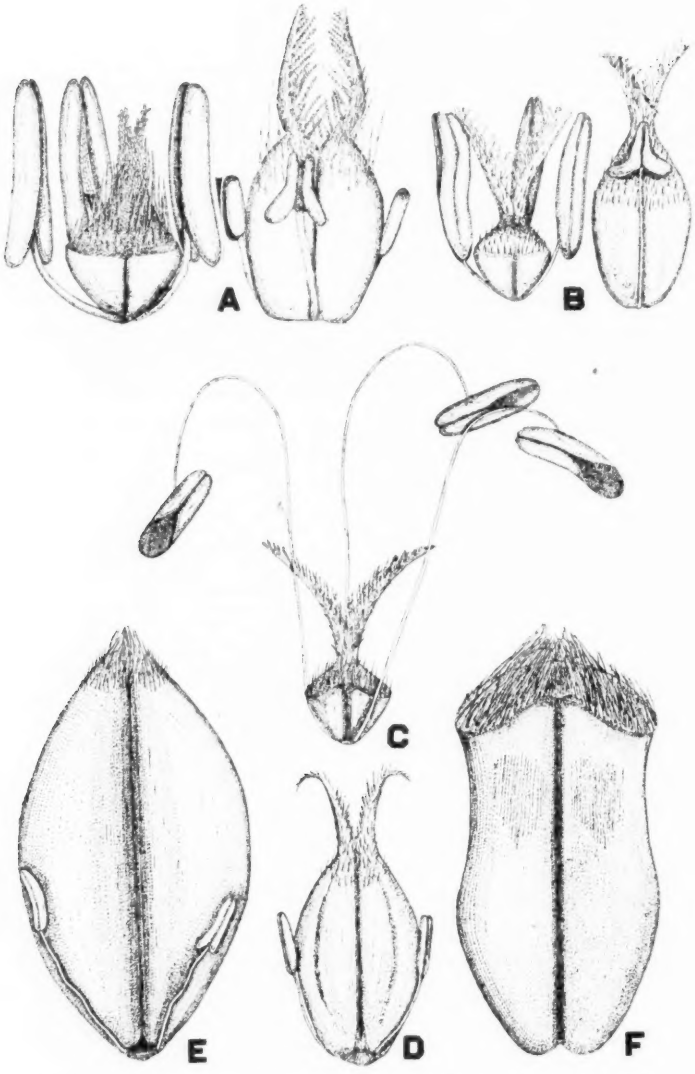


FIG. 1. Healthy and diseased flowers, and kernels of wheat. *A*, Flowers about three days before head should appear; at the left, from healthy floret, ventral aspect; at the right, from smutted floret, dorsal aspect; *B*, flowers just following emergence of entire head; at the left from healthy floret, ventral aspect; at the right, from smutted floret, dorsal aspect; *C*, flower from healthy floret soon after stamens are extruded; *D*, flower from smutted floret at about the same period of development as in *C*; *E*, smutted kernel and two aborted stamens at about the same period of development as in *F*; *F*, healthy kernel about six days after pollination.

A is enlarged 7.5 diameters and *B*, *C*, *D*, *E*, and *F* are enlarged 7.5 diameters.

ovary itself is nearly twice as long and somewhat broader than a healthy ovary (fig. 1, *a*). This greater length gives the affected pistil a different shape. The stigma of the diseased pistil is a little further developed and is more spreading than is a healthy one of the same age. One marked difference is the green color of the diseased ovary in contrast with the almost white color of the healthy one. Freehand sections of a diseased ovary show normal cells in the pericarp but the ovule is filled with the spores of the fungus which at this stage have light-colored walls and so pass unobserved to the naked eye when the ovary is crushed.

The stamens of affected flowers are much reduced in length and breadth and the anthers have a pale yellow color which contrasts strikingly with the pronounced green color of healthy anthers. The anther on the dorsal side of an affected pistil is usually elevated more than the two others and the long slender filament fits snugly in the groove of the pistil on that side (fig. 1, *b*). The lobes at the base of this anther are usually spread apart farther than those of the others giving it a peculiar straddling appearance (fig. 1, *a* and *b*). The pollen grains found in anthers from diseased flowers examined in this and later periods of development are pale-colored collapsed structures containing little or no protoplasm.

CONDITIONS FOLLOWING EMERGENCE OF HEAD

Diseased and healthy heads are easily differentiated just after the emergence of the entire head as the former have a blue-green color and the latter have a yellowish green cast. The diseased heads are also slimmer and one can detect at this time the foetid odor so characteristic of this smut. An examination of the flowers shows that growth has taken place in both diseased and healthy pistils but has been most active in the diseased ovary. The difference in color of diseased and healthy ovaries and anthers remains as described earlier. A section of the diseased ovary shows that the spore mass has turned dark so as to enable one to detect it with the naked eye. The spores readily drop out of free-hand sections. The green color of the smutted pistil is found to be due to chloroplastids in all cells of the wall of the ovary except the innermost and outermost layers. A section of healthy ovary shows that the cells containing chloroplastids are confined to a single layer in the ovary wall adjoining the innermost and colorless layer and to other cells near the sinus. The anthers of healthy flowers still have a green color and are about twice the size of anthers of diseased flowers (fig. 1, *b*).

CONDITION AT BLOSSOMING TIME

At blossoming time the difference between diseased and healthy plants is apparent. The diseased plants have shorter culms and diseased heads

are usually shorter and much slimmer, being smaller in both diameters. An examination of a large number of heads will enable one to find occasionally an affected head that is as long and as broad as healthy heads; on the other hand, healthy heads are sometimes found that are as short and as slim and are borne on as short culms as affected heads. Edler[1] observes that Squarehead wheat when affected with stinking smut produces heads much longer and looser than is normal. Appel[2] confirms these observations and believes this condition of the smutted plant is a reversion to the original type. Miczynski[3] found a lengthening and loosening of heads of several varieties of *Triticum compactum* when infected by *Tilletia tritici*. Sperling,[4] while confirming the observations made on Squarehead wheat, found that stinking smut affects bearded wheat (Rauhweizen) less often and then does not cause the lengthening and loosening of the head as observed on Squarehead. In fact, it is difficult, he says, for anyone except an expert to tell the difference in appearance between smutted and healthy heads. Diseased heads still have the blue-green color which gives them an immature appearance as does also the absence of extruded stamens which are so conspicuous on healthy heads (fig. 2, *a*).

An occasional diseased head is found of which the upper portion has died, the dead portion usually being curled and twisted. A few diseased heads are found on which the upper two or three spikelets, and in a few cases an occasional one farther down, contain healthy florets. One head shows only healthy spikelets on one side and only smutted ones on the other. Several cases were noticed at the margin of the plat where some plants had stooled in which one or more healthy heads were found in a stool with smutted ones but more often all heads were smutted or all healthy.

While it cannot be considered a constant character numerous affected culms show a peculiar twisting of the upper leaf and sometimes of the leaf below. This twisting is similar to that observed frequently on wheat culms affected with loose smut.

An examination of the flowers at blossoming time showed much the same conditions as noted earlier except that the anthers of healthy flowers

[1] Edler, W. Einwirkung des Frostes auf den Squarehead-weizen. Illust. landw. Zeit. 1903, No. 60. Cited from Edler, W. Zur veränderlichkeit des Squarehead-zuchtern. Fühling's landw. Zeit. **55**: 601–606. Figures 1–2, 1906.

[2] Appel, O. Zur Beurteilung der Sortenreinheit von Squarehead-Weisenfeldern. Deut. landw. Presse **1906**: 465–466. Figure 1.

[3] Miczynski, K. Der Einfluss des Steinbrandes auf die Form der Weizenähren. Zeits. landw. Versuchs. in Oesterreich **1911**: 232–235. Figure 1.

[4] Sperling, E. Der Einfluss des Steinbrandes auf die From des Weizenähren. Illust. landw. **32**: 865. 1912.

had now a yellowish color. At least one floret of each spikelet had extruded its anthers by means of a rapid elongation of the filament (fig. 1, *c*). The stigma was fully expanded and in case of those flowers in which the anthers had been extruded, the stigma bore many pollen grains. The anthers of diseased flowers (fig. 1, *d*) had not changed in size and color from that described earlier.

FIG. 2. Healthy and diseased heads of wheat. *a*, Two smutted heads (left) and one healthy head, at blossoming time. The extruded anthers are conspicuous in the healthy head. Natural size. *b*, Side view of healthy (left) and smutted heads of wheat near time of maturity. Natural size. *c*, Back view of healthy (left) and smutted heads at same stage as is shown in *b*. The healthy heads in both cases are larger. Natural size.

CONDITION FIVE TO SIX DAYS AFTER BLOSSOMING

Five to six days after blossoming the slim condition of affected heads is not so noticeable. Many are just as plump as healthy heads and might be mistaken for them except for their blue-green color. This plumpness of the head is especially noticeable when viewed so as to expose the side of the spikelet which has become somewhat expanded due to the increasing plumpness of the diseased kernel. In such cases the side aspect of an affected head is as broad as the healthy head while the front aspect is narrower.

While affected culms can be found at this time which are as tall as healthy ones, in general the healthy heads stand highest. This greater height is not due to the greater length of any particular internode. Often all

FIG. 3. Fifty healthy and fifty smutted kernels at maturity. Natural size.

internodes share in the elongation. In the case of wheat plants affected by loose smut where mature culms are shorter than healthy ones, the difference is due to the failure of the upper internode of affected plants to develop as much as healthy ones do.

In healthy florets the empty and shrunken anthers have fallen or are entangled in the withered stigma. In diseased florets they are either carried upward with the growth of the ovary, the filaments being broken and shriveled, or remain below and attached to the filaments. In several cases the dorsal anther was located near the top of the ovary, the others being below the middle.

The healthy kernel is grayish white in color with a small amount of green showing in the sinus on the ventral side. It is shield shaped, the flattish top being covered with hairs and the withered stigma. The diseased kernel is dark green in color, its sinus very shallow, and it has a

plumper appearance than healthy ones. It is tapering at both ends, the withered styles completing the point at the top. The size of the two kernels is much more equal than they have been before, although the smutted one has greater equatorial diameter and is a little longer (fig. 1, *e* and *f*).

CONDITION NEAR MATURITY

As plants are nearing maturity (July 15) the field has a golden appearance and an examination shows that the healthy kernels are in the pasty stage. Healthy heads have a greenish yellow or golden yellow color, depending upon their ripeness. Green streaks appear at tip and margins of outer glumes and lemmae and at the margin of paleae. Powdery mildew is present on many heads and may affect somewhat the color of the heads at this time.

The smutted heads look much greener than the others, the golden color possessed by healthy heads being absent. The outer glumes are green, the lemmae are greenish white with an occasional tinge of yellow and the paleae are green at their margins. Many affected heads have a dead appearance due to the yellowish brown color of paleae and lemmae particularly at the apex. This may be due in part to the mildew. The enclosed anthers are plainly visible through the transparent paleae. The kernel is still quite green although a yellowish white color shows at the apex and along the sides. The apex of the kernel shows in most affected heads because of the spreading glumes. Culms of both healthy and of diseased plants have a yellowish green color.

The side of heads of smutted wheat is about the same width as healthy heads but the front aspect of healthy heads is wider. The contrast in color is greatest when the front or back of heads is seen. The angle of divergence of glumes is about equal in diseased and healthy heads (fig. 2).

The smut mass in the kernels has a mouse-brown color and is pasty. Beetles have been feeding upon it for the past two weeks.

CONDITION AT MATURITY

Observations made after the wheat has been cut and cured shows little difference from what was observed as wheat was approaching maturity. Fifty smutted heads were measured. The average dimensions were 8.4 by 12 by 69.2 mm. as compared with 9.5 by 12.7 by 74.4 mm., the average for fifty healthy heads. The heads and all flowering parts of both healthy and smutted plants have lost all green color previously observed. The healthy kernels have a golden yellow color and a deep sinus. The smutted kernels are gray or gray-brown in color and have a

shallow sinus. The dry anthers can still be found enclosed with the smutted kernels. Affected kernels when broken reveal a dry caked, nearly black mass of spores which can be easily crushed to a powder. One is surprised to find at this time that the smutted kernels are smaller in all diameters than are healthy ones. Measurements of more than a hundred smutted kernels gives an average of 2.6 mm. for one diameter, 2.3 mm. for the other, and 5.1 mm. for the length. One hundred healthy kernels average in the same order 3.1 by 2.6 by 6.1 mm. (fig. 3). With the idea that there might be less difference between diseased and healthy kernels when swollen with water, measurements were made of twenty smutted and twenty healthy kernels that had been soaked in water for one day. Under these conditions the average dimensions for the diseased kernels were 2.8 by 2.6 by 5.4 mm. and for the healthy ones 3.3 by 2.8 by 6.5 mm. While all have swollen from 0.2 to 0.4 mm. the proportion between healthy and smutted is practically the same as before.

For heads of equal length there are more smutted kernels in a smutted head than healthy kernels in a healthy head. This is due to the formation of four and sometimes five smutted kernels in many of the spikelets. There are rarely ever less than three such kernels except on the small lower spikelets where the corresponding spikelets on healthy heads are sterile.

The specific gravity of smutted kernels is much less than healthy ones which condition is made use of in removing smutted kernels from healthy ones in seed treatment.

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SOME BARK DISEASES OF CITRUS TREES IN FLORIDA[1]

J. G. Grossenbacher

With Nine Figures in the Text

Citrus trees, like other plants, are subject to various ailments. These become evident in poor, abnormal growth, or as localized injuries on the leaves, twigs, fruit or bark. Some of these troubles are due to certain organisms, others appear to result from adverse conditions of the environment. Many of the diseases which are primarily due to fungi may be prevented by covering the parts likely to become infected with some fungicidal substance, of a kind and strength that is not injurious to the cultivated plant. The treatment or prevention of troubles which are chiefly due to an adverse environment is still in a rather primitive state, because we know too little about the conditions necessary for the required development of the more or less modified plants that we have evolved through selection and culture.

In most of the citrus growing sections of Florida there is sufficient rainfall for good tree-growth, but in some places a water shortage may prove more or less injurious during certain seasons of the year unless the need is met by irrigation. Since water passes very rapidly through the sandy soils, its relative availability to citrus trees, during most of the time, depends chiefly upon the level under a grove, of the uppermost layers of perennially moist soil. In some places the water-table may be too high for good tree-growth, as is often the case on flatwoods land and on land reclaimed from swamps. It is a well known fact that the shoreline or water-level of the numerous lakes may vary greatly from year to year or from season to season. This variation which indicates a change in the height of the water-table in the ground, often amounts to several feet and probably has a marked influence on the growth and bearing capacity of citrus trees.

This effect of the variation in the water-supply is marked in regions where the subsoil, to considerable depth, consists mainly of coarse sand and where,

[1] This paper is a generalized summary of detailed investigations carried on along the different lines. Since the purpose of the paper is to give a brief general view of the subjects, the various details regarding the making of numerous isolations, inoculations, and microtome sections of affected tissues, are not included. The results obtained are given only in general terms.

even in rainy seasons, the water-table is far below the surface; but it is especially noticeable in localities where a layer of clay or some other partially impervious material near the surface sustains a temporary water-table during a portion of the year. The water above such a shallow layer is exhausted during a drought and the impervious nature of the layer hinders the rapid upward movement of water from deeper layers, thus inducing severer droughts than occur on soils with a lower water-table. In both of these types of localities irrigation is profitable, and in the latter dynamiting would probably aid in equalizing the water supply in that the rapid downward and upward movement of the soil water is aided by breaking up the hardpan.

The most uncertain and doubtless the most farreaching environmental factor influencing the citrus industry in Florida is temperature. As a matter of fact, the occurrence of occasional periods of low temperature at unseasonable times is not only the factor limiting the extent of the business, in that trees may be killed to the ground over night, but it is responsible for some slighter bark injuries which occur during the more moderate cold snaps, that are of more frequent occurrence. These injuries often result in localized bark diseases.

That marked variations in the water supply and untimely cold snaps influence the health of citrus trees is shown by the fact that a series of wet years or a succession of dry years is usually followed by the prevalence of one or more diseases which had not been so troublesome immediately before, while following severe droughts or winters in which low temperatures occurred while the bark was growing, diseases of the bark and twigs often become alarmingly conspicuous. Such droughts or cold periods coming when bark-growth is in abeyance do not prove injurious even if severe, while their occurrence when the bark in certain parts of trees is still growing may be very disastrous.

Different diseases dominate at different times, and the same relative destructiveness of a particular trouble may recur after a time. Swingle and Webber, who were studying the diseases of citrus in Florida for the United States Department of Agriculture from 1892 to 1896, leave the impression in the report of their work[2] that the principal diseases ranked as follows in regard to their economic importance: blight, dieback, sour scab, sooty-mold, foot-rot, and melanose. Some years later withertip was shown by Rolfs,[3] to be a very destructive and wide-spread malady.

[2] Swingle, W. T., and Webber, H. J. The principal diseases of citrus fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. and Path. Bul. 8: 9–42. 1896.

[3] Rolfs, P. H. Withertip and other diseases of citrus trees and fruits caused by Colletotrichum gloeosporioides. U. S. Dept. Agr., Bu. Plant Ind. Bul. 52: 9–22. 1904.

The disease known as dieback has varied from time to time in its importance, although some of its phases are nearly always seen in abundance. In the nineties sour scab is said to have been confined chiefly to lemon (*Citrus medica* var. *Lemon*), lime (*C. medica* var. *acida*), and sour orange (*C. aurantium* var. *amara*), and only rarely to have occurred on grapefruit (*C. decumana* nearest to var. *Pomelo*). Melanose was then described as a new disease which was said to be spreading rapidly. At the present time the annual loss from sour scab on grapefruit is very large indeed, and that from melanose on orange is often heavy, owing to the greater susceptibility of melanosed oranges to decay. Sour scab, especially, seems to have increased in its destructiveness on grapefruit during the past three years. At the present time some of the bark diseases, like canker, gummosis, and foot-rot, are causing considerable alarm in some sections of the state, while sour scab is more generally dreaded owing to its wide distribution and great economic bearing on grapefruit growing. The so-called blight is only rarely heard of now, and when found often after more careful examination turns out to be foot-rot.

We have changed or "improved" wild plants by selection and culture so that they yield more and choicer economic products than they did in their wild state, but in so doing we have also modified the requirements of the plants. The natural conditions necessary for their normal development in the wild state are only partially understood and the needs of the improved plants are even more baffling. Cultivated plants are therefore usually dependent upon intelligent culture for their required development and those most highly specialized need most consistent and continuous care. When the surroundings of such modified plants are allowed to revert or are not kept up consistently, marked injuries or diseases may follow. The plants which have sustained least artificial modification may be more hardy when grown in the proper climatic conditions simply because when given only intermittent attention the natural surroundings suffice for their full development. Trees carrying a heavy crop of fruit and having a very large leafage are much more seriously affected by sudden marked changes in the surroundings than are trees with only moderate leafage and small crops of fruit. A severe drought occurring at an unseasonable time has a more disastrous effect on heavily loaded trees than on those with a light load; drastic applications, or the omission of timely fertilization are also most harmful to the more refined or modified varieties of Citrus, or to trees bearing heavy crops. Unfortunately our knowledge regarding the requirements of citrus trees when pushed to high productiveness is too limited to insure continuous success. Sometimes the wrong guess is made at some critical turn, and consequently serious injuries and diseases result.

Broadly speaking, citrus diseases may be conveniently arranged in two classes, although one malady may have symptoms which appear in both categories. They can be grouped as diseases of the bark, and diseases of the leaves and fruits. That is, the troubles affecting the temporary and those affecting the more permanent parts. In some instances bark diseases, especially those of the roots, are not evident until after the normal functioning of the leaves has become deranged and show signs of trouble. The bark diseases in general are not well understood and no method has as yet been devised that always may be depended upon to prevent them; but trees affected by these maladies often can be helped by cultural and surgical means so as to aid them in overcoming such tendencies, and the healing processes can be encouraged. On the other hand, the diseases more typically affecting leaves, succulent twigs, and fruits are often preventable, even with our limited knowledge, if proper treatment is given early enough.

BARK DISEASES AND SUGGESTIONS FOR THEIR TREATMENT

Citrus trees are affected with a group of bark diseases which appear to have some things in common in that the growth periods of such affected trees are more or less out of agreement with the surroundings. Ordinarily the weather and soil conditions, including cultivation and fertilization, are such as to induce or permit both twig and bark growth only at certain seasons of the year, but under certain circumstances such growth is started or continued at times when because of the weather and soil conditions this normal completion is impossible. This group consists of such diseases as gummosis, foot-rot (crown-rot), dieback, canker, and withertip. These diseases begin with injuries which occur in the bark of certain rather definite parts of trees. The phase of canker affecting the bark differs, however, from the typical bark diseases because it attacks only the cortex while the others arise from troubles in the phloem and cambium.

Gummosis

The disease known as gummosis begins with the discoloration or disintegration of portions of the inner bark on the trunk or branches. Sometimes this is just above the roots and on the lower sides of large branches, but more frequently it occurs three decimeters or more above the roots or below branch crotches. It also represents the gumming stage of both foot-rot and scaly bark (fig. 1). The bark of the affected areas commonly has one or more cracks or clefts through which "sap" or gum exudes and in some cases the clefts occur where the inner bark is not injured enough to gum, as shown in figure 2. In the early stages "sap" oozes more or

less freely from affected areas during periods of sap flow. In the larger injured areas this "sap" often sours while in the smaller ones souring may not take place. In all cases gum eventually collects in the disintegrated inner bark and may exude through the clefts in the outer bark. In cases where much souring of the "sap" occurs the outer bark, over the entire area affected, usually dies and eventually a ridge of callus develops around the dead area. The affected portions soon appear sunken owing to the fact that the part of the tree covered with live bark grows in thickness while the bark of the dead areas dries and shrinks. Some phases of this disease have been given special attention in California.[4]

Apparently, gummosis and foot-rot merge into each other, both in their distribution on trees and in regard to the nature of the original injuries from which the two troubles develop. When the injured area of inner bark is large so that the outer bark also dies in a short time over the entire affected region, gumming is comparatively slight and gum only accumulates around the margin of the wound although considerable "sap" may run out at cracks in the affected area. However, if the injured places in the inner bark are comparatively small or are in very narrow strips, the outer bark over them may live for some time and the production of new wood around the margin of the injured inner bark, or on the wood surface just inside the disintegrating inner bark, lifts the outer bark away from the wood and thus forms pockets in which gum accumulates. Microscopic examination of the early stages in which gum is just beginning to form shows absolutely no difference between the gummosis and foot-rot types of injuries.

In instances where the inner bark had been less seriously affected or where the injured areas are numerous but very small and close together little or no souring of the "sap" occurs. The wood inside the disintegrated inner bark develops new, although rather imperfect bark which on further growth in thickness causes the old outer bark to crack and scale more or less; thus the imperfect new bark surface becomes exposed, here and there, through masses of gum and old scaly bark (fig. 1). This form of the disease often occurs high up on branches and is known as scaly bark.

The organisms so often found on and in the dead bark that is scaling off are only rarely obtained from affected areas in the early stages of this disease and for that reason one gets the impression that such organisms are of only secondary importance and can have no relation to the first cause of the injuries resulting in disease. The fact that practically all inoculation tests made with these organisms prove negative also supports the same idea.

[4] Smith, Ralph E., and Butler, O. Gum diseases of citrus trees in California. California Agr. Exp. Sta. Bul. 200: 235–270. 1908.

Foot-rot or crown-rot

When the inner bark of roots is injured the dying outer bark is kept moist by the soil and therefore may decay even before gumming has become very copious. We speak of this trouble as foot-rot or crown-rot. An advanced stage of it may be seen in figure 3, which shows that the death of roots must be followed by cutting away the corresponding portion of the top.

According to Curtiss[5] foot-rot of citrus was first noted in the Azores in 1832. It is said to have destroyed about a fourth of the trees there in ten years; but by 1873 the disease had disappeared from the Islands. In the meantime, however, it had been noted as occurring in the citrus growing portions of Europe. The disease was first noted in Florida during the late seventies.

Curtiss considered that foot-rot and gummosis are the same disease. His characterization of the trouble is good: "The prominent symptoms of foot-rot are exudation of a gummy or sappy fluid from near the base of the trunk, and decay of the bark in that region and of the roots below. The flow of gum and attendant decay extend upward and in a lateral direction, until it is girdled, also penetrating successive layers of wood. In some cases gum exudes from cracks in various parts of the trunk, or even on the branches, and in others the decay progresses without emission of gum. Attendant or premonitory symptoms are excessive and rather late blooming, the flowers being small and mostly unfruitful, and arrested or unnatural development of the foliage, which becomes yellow and drops. The disease manifests itself in the top, on the same side as the base, and makes like progress above and below." "It almost invariably originates at the base of the trunk, and soon destroys the main crown or lateral roots. About the first indication of the disease is a foamy or frothy substance exuding from a crack in the bark." "In cutting out this diseased part very often a small pocket of gummy substance will be found. The wood in the vicinity of the trouble looks yellow and diseased, and smells sour."

Swingle and Webber[6] also give some observations regarding the general characters of the disease, and some suggestions regarding treatments. Hume[7] quotes some statements from Coogler that are especially interesting. "When I first began growing citrus trees in this county (Hernando) in 1867, there was no such thing known as foot-rot, and if it then existed

[5] Curtiss, A. H. Foot-rot, sore-shin, or gum disease. Florida Agr. Exp. Sta. Bul. 2: 29–35. 1888.

[6] l. c., pp. 28–34.

[7] Hume, H. H. Foot-rot. Florida Agr. Exp. Sta. Bul. 53. 151–155. 1900.

FIG. 1. Orange tree having the scaly-bark stage of gummosis.

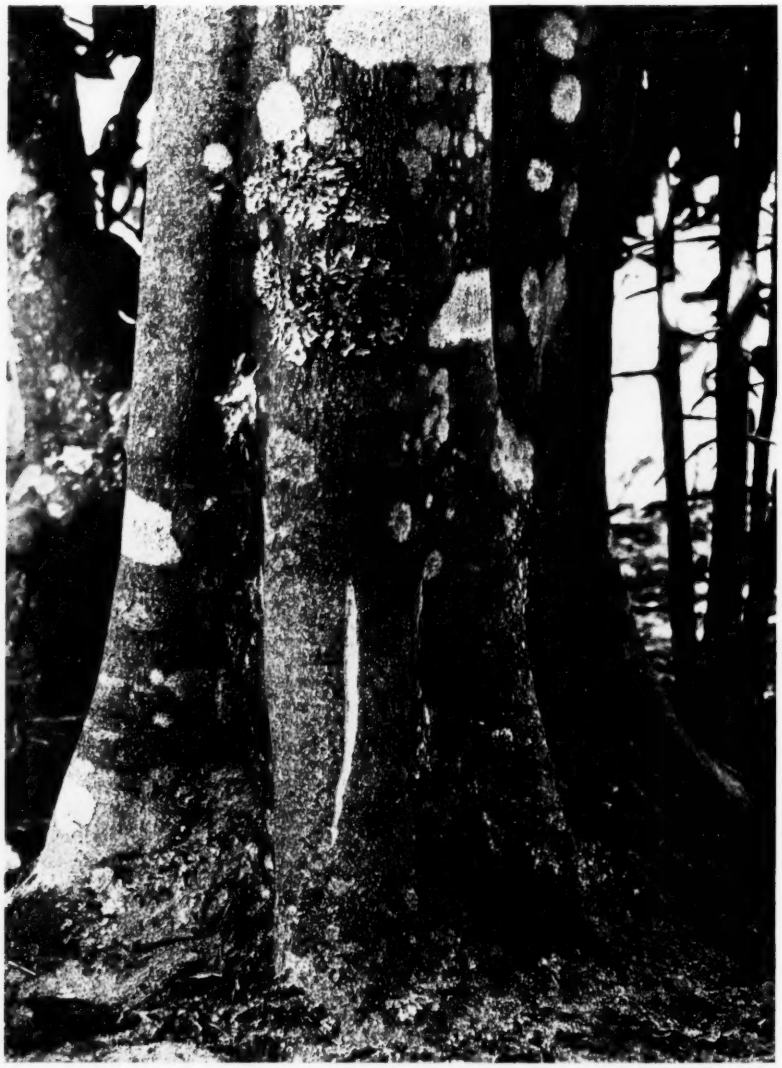

FIG. 2. Bark-cleft at crown of seedling orange tree, showing by its width the amount of growth since bark was burst.

it was wholly unnoticed. The year 1878 was a very wet one, for it rained almost continually during the entire year. When the sap began to flow in the citrus trees the following spring (1879) it was noticed that in many trees it exuded from the bark at or near the ground, but no one paid any attention to it. This was really the commencement of the foot-rot in this county, so far as we can ascertain."

Former studies by the writer[8] on a very similar bark disease occurring on deciduous fruit trees, also throw some light on the development of foot-rot on citrus. The environmental factors having a causal relation to the two diseases are apparently comparable and in some respects iden-

FIG. 3. Foot-rot on a seedling orange tree, in advanced stage, showing dead roots and the removal of corresponding portion of dead top.

tical. Sections of the earliest stages found are remarkably like some shown on plate 1 of my paper on a histological study of crown-rot.[9] The subsequent stages in the development of foot-rot differ somewhat from those of crown-rot, but mainly it seems because of the natural differences between citrus and apple trees. A histological study of the development

[8] Crown-rot, arsenical poisoning, and winter-injury. New York State Agr. Exp. Sta. Tech. Bul. 9: 367–411. 1909.

Crown-rot of fruit trees; field studies. New York State Agr. Exp. Sta., Tech. Bul. 23: 3–59. 1912.

[9] Crown-rot of fruit trees: histological studies. Amer. Journ. Bot. **3**: —. 1916.

of foot-rot from the material now on hand, will doubtless add much desirable information to our knowledge of this disease.

As stated above, the beginning of this disease seems to be identical with that of gummosis except that foot-rot more commonly starts in the upper angle of crown roots. Among clumps of seeding trees it often begins where the trunks press against each other, but sometimes begins on underground portions or even in the gutter-like depressions between two roots. In case of some trees in foot-rotted groves, the bark, in the lower angle that branches make with the main trunks and in the upper angles that roots make with the trunks, is cracked without the further development of injury as shown in figure 2. However, sections through such healed ruptures show that a cleft had also occurred at right angles to the visible one. A separation of the tissues in the inner phloem had resulted in a tangential rupture extending two to five centimeters on both sides of the radial cleft shown in the figure. The callus growth from both sides had been so prompt that a complete fusion resulted. The wound-tissue mass is easily seen in cross-section knitting the old and new bark together.

The occurrence of clefts in gumming bark and the presence of similar clefts in the corresponding parts of other trees, suggests the idea that perhaps the development of the clefts and the injuries in the inner bark that invariably precede the development of cases of foot-rot or gummosis go back to some common but unknown cause. Their early stages usually become noticeable from March to July.

Studies of forests have shown that after trees attain a certain age the closeness of the stand induces self-pruning by starving out the lower branches. At the same time, the lower part of the trunk grows less and less in thickness per season and one or two years' growth at its base often may be wholly omitted while much growth occurs in the upper parts of the trunk. In that way a trunk of a tree which in youth tapers very rapidly from bottom to top, is converted into one that tapers much less. It has been found by years of experience in the forests of Europe that when trees of such a close grown forest are thinned out the lower part of the trunks of the remaining trees immediately begin growing more rapidly in thickness. At the same time it was also observed that the bark of the upper roots and about the lower part of such tree-trunks was very likely to become affected and decay, from one to three years after the forest was thinned. In these instances it is evident that foot-rot or crown-rot is somehow related to changes brought on by thinning out the trees in connection with the resulting changes of trunk-growth, and it seems that either the amount or the *unseasonableness* of the growth thus induced on the upper roots and at the base of the trunks has a causal rela-

tion to the disease. Wester[10] described a case where the trouble was apparently caused by an unseasonable and severe drought.

Foot-rot and gummosis seem more prevalent in groves which are subject to considerable fluctuations in the water supply, and especially in places where in dry seasons a very marked shortage of water results. These bark diseases usually become most apparent during the first and second growing seasons following injurious droughts or after low temperatures that occurred while the bark was only partially dormant. This may be summed up by saying that these bark diseases apparently develop from injuries arising in the inner bark of certain characteristic regions of trees in which bark growth often occurs at times during which the environment may be abnormal and inimical to growing tissues. Grove management, then, should be such as to induce timely and steady growth of trees during the normal seasons of growth, as well as to encourage dormancy during the dry and winter periods. Trees must, of course, also have enough room or light-exposure to permit the functioning of sufficient leafage to elaborate enough food for the growth of the lower part of the trunk and the roots as well as for the growth of the top. If the food elaborated by the leaves during the best part of the growing seasons is all used as it courses downward in the bark of trees, so that practically none of it reaches the base of the trunk and roots until *after* the upper portions of the tree have become dormant, it is evident that the bark on the lower part of the trunk and roots may grow after the close of the regular vegetative periods and thus be subject to injury by the occurrence of unusually severe periods in the environment.

It is impossible at present to draw any definite conclusions as to the actual cause of foot-rot of either forest or fruit trees, but, as stated above, it appears that somehow the timeliness, manner and amount of growth of bark occurring at the base of trees in relation to the more critical or limiting environmental factors (drought, water-logged soil, low temperature), are connected with the development of the trouble. Here, as in gummosis, affected areas of the inner bark in the earliest stages of the disease seem to be free of pathogenic organisms of any kind. It is highly probable, therefore, that foot-rot is not primarily due to such organisms.[11]

Surgical treatment of foot-rot and gummosis

Considerable reliable information regarding the care of wounds in trees is available. This care should be applied to trees already diseased,

[10] Wester, P. J. The situation in the citrus district of Batangas. Philippine Agr. Review **6**: 125–130. 1913.

[11] Briosi, G. Intorno al mal di gomma degli agrumi (Fusisporium limoni Briosi). Atti R. Acad. Lincei (Roma) ser. 3. **2**: 485–496. 1878.

as long as the trees pay for the time and space given them. Bark which has become affected should be removed as early as possible by cutting it around the margin of the injured area with a sharp knife held so as to cut the bark at right angles to the surface. The affected bark should then be peeled and scraped off. Tree surgery of this kind enables the living bark along the cut edges to grow rapidly in the direction of the wound and, if the exposed area of dead wood is not too large, it is soon covered over with a shell of living wood. If, meanwhile, the exposed wood has been protected by paint no decay will have set in and the efficiency of the tree-trunk as a water conductor will not be seriously impaired. On the other hand if dead bark is left on, or dead wood is allowed to become weathered, the wood often dies to the center of the trunk and thus reduces the water carrying capacity of the tree to such an extent that roots on the affected side die and the tree becomes injuriously affected by droughts and so forth. In case the wounds are large it therefore pays to cover the exposed wood with some good paint a few weeks after treatment. However, if much wood having a white, living surface, is exposed by the removal of affected bark, it might be covered with grafting wax at once instead of later with paint. Wax permits the development of new bark in such places, while exposure or paint kills the tissues of the outer surface and thus prevents the formation of new bark. This applies to roots as well as to trunks. The soil removed from about the roots, in order to treat them for foot-rot, should be replaced shortly after the treatment, or at least before there may be danger of frost.

When severely affected trees are found before the vitality of the bark above and below the dead girdle has become much reduced, inarching a sour seedling stem set at their sides, has been found to prolong the life of such citrus trees. Bridging such dead bark-girdles on apple trees with two or more vigorous young shoots, by grafting them in the sound bark above and below the dead girdle, has also proved practical and may possibly prove so in some cases of citrus foot-rot.

Dieback

This bark disease is very widely distributed in Florida and may occur on any variety of citrus, but it is most noticeable on grapefruit. The worst feature of dieback consists in the dying back of young shoots from which most of the leaves had fallen after attaining practically full size. The small, original buds in such leaf-axils often die, and, during the next following period of growth, rosettes of substitute or adventitious buds arise as shown in figure 4, the development of which results in a very bushy growth from which dead shoots project as shown in figure 5.

FIG. 4. The multiple-bud phase of dieback on grapefruit shoots showing in addition some bark lesions above at right.

FIG. 5. Grapefruit tree affected by dieback, showing numerous dead branches which had hardened in bent positions.

During the time such shoots are yet growing in length they are often so limp that when the wood is eventually hardened in them they are fixed in more or less abnormal positions. Twigs produced on dieback trees when both air and soil are sufficiently moist usually maintain normal positions and harden more or less completely, although certain places in the bark may remain imperfect and develop gum which may exude through ruptures in the outer bark or be retained in cavities in and under the bark where it was formed. The bark of affected shoots becomes yellowish and more or less mottled with gummous areas and eventually such twigs die back from the tip to a point where enough normal bark tissues remain to permit the development of new buds that may continue the elongation interrupted by the dieback shoots. In some cases the edges of the ruptured bark turn back and the entire broken and protruding surface assumes a reddish-brown color.

The rind of fruit on dieback trees is also more or less blotched by the occurrence of gummous areas in it. In case of bearing orange trees, this is often the only phase of the disease to become evident. These patches are first of a yellowish color and subsequently become darker. The affected spots may eventually merge into each other and thus give rise to various sized patches which become more or less checked as the outer rind dries out. Although this phase of dieback when occurring alone does not affect the trees very seriously, it causes great losses during certain seasons owing to the fact that affected fruits often split (fig. 7, *a*) and drop so extensively that by picking time only a small fraction of the original crop, and that very inferior in keeping qualities, is found on the trees. In seasons in which decay is especially abundant in the groves one-half to three-fourths of such remaining dieback or "ammoniated" fruit may rot in transit to market.

The causes of the disease. The cause of dieback has not been fully established, but it is said to have some relation to the relative abundance of nitrogen in soils and perhaps also to the form in which the nitrogen occurs. Fowler[12] in his interesting account of this disease gave some notions regarding its cause that still prevail. He maintained that the use of improper fertilizer or the improper use of good fertilizer is the cause of the trouble. Heavy applications of barnyard manure or other rich natural manures, or penning domestic animals among the trees were thought to have a causal relation to the disease. His contention is, however, that improper grove treatment only furnishes the predisposing

[12] Fowler, J. H. On "The Dieback" in orange trees. Proc. Florida Fruit Growers Assoc. **1875**: 62–67. 1875.

factors and that a fungus is the cause of the disease. Webber[13] subsequently enlarged on some of these ideas. In some cases stable manure along with commercial fertilizers have been liberally applied to dieback trees by *inexperienced* growers and resulted in greatly improving their condition, rather than in making the disease worse, as would generally be expected. Dieback seems to occur most frequently in portions of groves needing drainage, although it also occurs on high sandy land where the nitrogen content is very low and where only meager quantities of fertilizer are applied.

Some of the results obtained by Floyd,[14] at the Florida Experiment Station, indicate that, in addition to the unbalanced condition of the soil water as a nutrient solution, some deleterious substances the tree takes up from the soil may be, at least partially, responsible for the production of imperfect bark and wood in shoots of dieback trees. A conclusion recently announced by Lipman,[15] from the University of California, maintains that dieback trees lack nitric nitrogen, because organisms occurring in the soil convert all nitrogen present to ammonia, which is either absorbed as such by the roots and causes injury, or escapes into the air as a gas. Some of the writer's experiments of the past two years confirm the opinion often heard among the growers that this disease may be "cured" by the application of copper sulphate to the soil about affected trees. This is a rather peculiar and interesting fact that will be discussed in a later paper.

Withertip

This also is essentially a bark disease, although the fungi considered to be a secondary cause of the trouble are found, too, in dead spots of both leaves and fruits[16] of Citrus as well as on nearly all parts of other dead plants. The most conspicuous characteristic of the disease consists in the withering of twigs and shoots. Most of the withering twigs shed

[13] Webber, H. J. Fertilization of the soil as affecting the orange in health and disease. U. S. Dept. Agr. Yearbook, **1894**: 193–202. 1895.

Swingle, W. T., and Webber, H. J. The principal diseases of citrus fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. and Path. Bul. 8: 14–20. 1896.

[14] Florida Agr. Exp. Sta. Ann. Rept. **1909**: 63–69; **1912**: 102–124; **1913**: 30–53; **1914**: 30–45.

[15] Lipman, C. B. The poor nitrifying power of soils and possible cause of "dieback" (Exanthema in lemons). Science **39**: 728–730. 1914.

[16] Rolfs, P. H. Withertip and other diseases of citrus trees and fruits caused by Colletotrichum glocosporioides. U. S. Dept. Agr., Bu. Plant. Ind. Bul. 52: 9–22. 1904.

Clausen, R. E. A new fungus concerned in withertip of varieties of Citrus medica. Phytopath. **2**: 217–234. 1912.

their foliage before they die, but some wither more suddenly and before the leaves drop. The latter phase of the trouble is often conspicuous in April and usually consists in the withering of the succulent young shoots of the growth of the spring, while the former phase of the disease is usually

FIG. 6. Budded orange tree that bore heavy crop in 1914. Bark slightly injured at base of large upper branches Nov. 20, 1914. Its tops died with withertip in summer of 1915.

most conspicuous in midsummer. Affected succulent shoots appear to wither from the tip backward, while in the case of the other type some of the bark, at a point from a few to many decimeters back of the tip, is found affected or even dead before the twig or branch in question shows any signs of withering.

If the second type of withering occurs in a grove it usually makes its appearance during the latter part of, or following severe droughts, or after the occurrence of untimely cold snaps like that of November, 1914. In some cases it develops only on trees which had borne a very large crop to maturity. Twigs bearing ripe fruit often wither and die, and following that, the attached fruit either drops or decays. Owing to the fact that this most important phase of the disease develops chiefly on trees subjected to severe conditions during a part of the season, it appears as though irregularities in the water and food supplies in conjunction with severe periods in the environment may be the principal predisposing factors. It was found that many slight interior bark injuries sustained by some nodal regions of branches, and by some crotches, from the cold snap occurring November, 1914, resulted in much of this type of withertip. Some such bark injured trees continued to appear normal until July and then died back, appearing like that shown in figure 6.

All branches, leaves of which no longer receive enough light to prepare or elaborate the food needed for their growth, eventually die. That is nature's way of pruning a tree and ridding it of useless members. A similar result follows where the water conducted through the wood of a branch is insufficient to supply the needs of all the twigs and fruit spurs attached to it. The twigs and spurs of such a branch, the water conducting system of which is most advantageously connected with that of the main branch, may survive a severe drought without injury, while the less favored ones, or those using an excessive amount of water, may be forced to drop their leaves and eventually wither. When a tree is properly fertilized and given good cultural treatment as well as kept fairly free of its *useless* branches and withered twigs, the leaf spots and anthracnose spot of the fruit so commonly present in groves affected by withertip will be of minor importance.

Canker

The name canker has recently been applied by Stevens[17] to a disease that has considerable similarity to certain phases of dieback, and some characteristics suggestive of scab. It seems to have been brought to Florida from Texas, where it has been present for several years. At present canker is apparently confined principally to the northwestern and

[17] Stevens, H. E. Citrus canker. Florida Agr. Exp. Sta. Bul. 122: 111–118. 1914.

Wolf, F. A., and Massey, A. B. Citrus canker. Alabama Agr. Exp. Sta. Cir. 27: 97–102. 1914.

Berger, E. W., Stevens, H. E., and Sterling, F. Citrus canker. II. Florida Agr. Exp. Sta. Bul. 124: 25–53. 1914.

southeastern portions of the state, and it is in the latter section that most notice has been taken of it.

This disease affects the leaves, fruits and twigs of grapefruit, navel oranges, ordinary sweet oranges, and some other varieties of Citrus. The first indications of the disease on very young, tender leaves are usually shiny white and slightly raised spots about one-sixteenth to one-fourth inch or more in diameter, on the upper sides of affected leaves. On the fruit the cankers sometimes bear a resemblance to "ammoniated spots" that had been raised above the general surface, but more generally they appear as porous, flat warts of brown color, from one-sixteenth to five-sixteenths inch in diameter. The warts may occur singly or may be

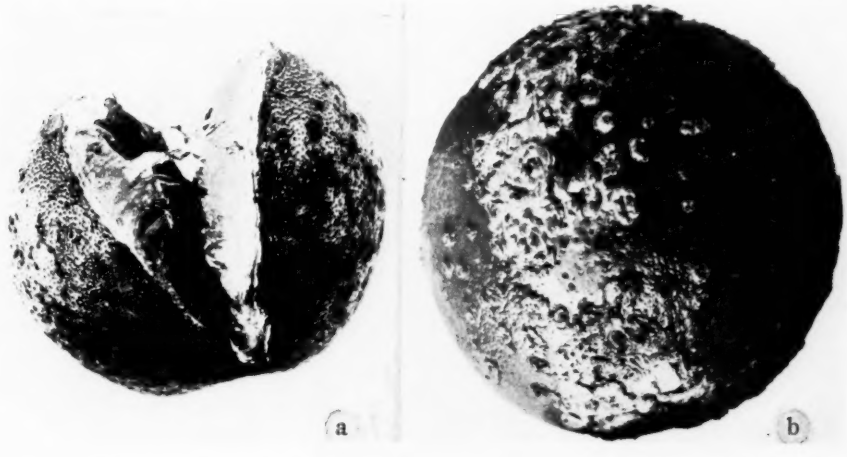

FIG. 7. *a*, Orange affected by dieback (ammoniated) and subsequently split by growth pressure. *b*, Navel orange, showing single and confluent cankers. Texas grove, crop of 1914.

merged into one, forming large cankerous areas (fig. 7, *b*). On the twigs, cankers often appear much like excrescences on dieback twigs except that gum usually is absent and the outgrowth is more corky and has less longitudinal extension. These warty outgrowths arise in the *outer* bark and have a brown color, fibrous corky texture, and measure from one-sixteenth to one-half inch in diameter (fig. 8). The cankers on the shoots develop in the cortex and seem never to affect the stele. In consequence the cankered outer bark is soon cut off from the normal tissues within by the development of a corky layer between them and the part outside, the dead bark is ruptured and eventually sloughs off as the affected shoot enlarges. On one-year-old branches the dead remains of the old cankers

are much weathered, and rather inconspicuous. The one-year-old portion of *b*, in figure 8, illustrates this point and shows the striking difference between the appearance of recent cankers on the current seasons growth (above) and the remains of old cankers as they still adhere to the one-year-old-branch (below).

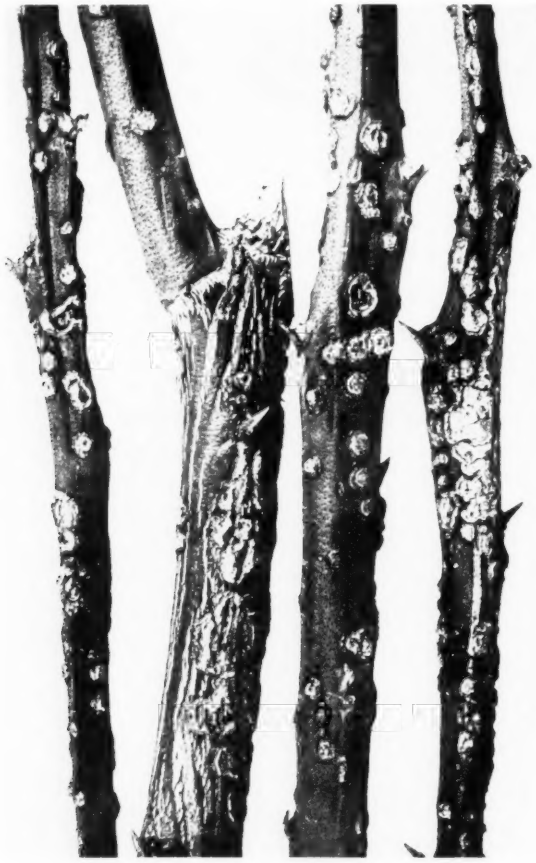

FIG. 8. Navel orange shoots and branches affected by canker. *A*, *C*, *D*, as it appears on newly hardened shoots. *B*, with two cankers above on new growth, and sloughing off of old cankered cortex from older growth below.

Cankered fruit tastes as good as smooth fruit, but owing to the fact that severely affected fruits are either culls or are of little commercial value, the greatest loss from this trouble is sustained in bearing groves. In a small grove in southern Texas where canker had been present for at least two seasons, about 80 per cent of the fruits of navel oranges and

grapefruit were considerably cankered in 1914, while only a few small spots could be found on the fruits of satsuma oranges in the same grove. In this as well as in another Texas grove the new growth was repeatedly sprayed with bordeaux mixture during its development in spring and early summer of 1915, and the disease failed to reappear. Some nurserymen in Texas as well as some growers in Japan claim that the application of fungicidal sprays keeps the disease in check. Apparently only the young fruits, leaves, and twigs are susceptible to this disease.

After being strongly impressed with the seriousness of canker, the Florida Growers and Shippers League, in cooperation with the State Nursery Inspector and the growers on the East Coast, formulated a plan in the early summer of 1914 to eradicate the disease from the state. Affected nursery and bearing trees were cut back and the prunings were

FIG. 9. Young grapefruit grove treated for canker. Affected portions of trees were cut back and stubs were painted with bordeaux paste. The new growth emerging from the bare, bordeaux-encrusted branches, was often severely affected by canker.

burned (fig. 9). The stubs were treated with bordeaux paste or other fungicides. In many cases the new growth subsequently emerging from the treated stubs soon showed the presence of canker as had been the case in several known instances in Texas, Louisiana and Mississippi. Bent on complete eradication a new method was devised of utterly destroying all affected trees and this has been applied with great energy ever since, but without eradicating the trouble.

The new method consists in applying kerosene with an admixture of about 10 per cent of crude oil, to affected trees by means of an ordinary spraying machine, and igniting the spray. In this manner even large bearing grapefruit trees are so severely burned and scorched as to kill them root and branch. Although this is apparently a most efficient method of disposing of affected trees the destruction of property is so great that it should be used only until some more economical means has

been found of keeping the disease within tenable limits. The results obtained in the two affected groves in Texas referred to above give at least a suggestion that should have a thorough trial.

In both 1914 and 1915 the inspection squad policing the canker-section of the lower east coast of Florida, reported a rapid decline in the number of new cases from July to late fall. In 1915 this decline was more marked than in 1914. Corresponding increases were also found from spring to June of both years. When it is recalled that new cases develop only during periods of elongation growth the matter becomes simple. The more rapid decline this year can unfortunately not be attributed to the work of eradication in view of the fact that the groves in the danger zone are no longer adequately fertilized and cultivated, and therefore do not have the usual number of late summer growths.

The cause of canker has not been definitely established as yet, but some evidence is at hand indicating that it may be of bacterial origin.[18] Yet, only a few scattered trees in a bearing grove may be affected, while the rest of them show no signs of the disease, while new sprouts breaking through the bordeaux coating of treated stubs, frequently develop abundant canker. Whatever may ultimately prove to be the cause of this disease, the writer became convinced early in 1914 that it is not due to fungi often found present in cankers as had been maintained by Stevens, Wolf,[17] and others. His own tests with bacteria isolated from young cankers were inconclusive.

This disease appears to have been in Texas at least six years. Owing to the fact that it is also present in Japan, the assumption has been made that it was introduced from there. But the citrus industry is old in Japan, and since it had not attracted attention there, it would seem that canker is either new to Japan or else that it is not as destructive a disease as is commonly assumed. Whatever may be the facts in this case, the present status of the question does not permit a rational conclusion regarding the original source of the canker.

The economic relations of this disease are very much like that of sour scab. Its only very serious phase, economically, consists of its effects on the fruit. All severely affected fruits are culls, and may drop as soon as they are ripe. Owing to the superficial nature of the bark canker, affected trees grow and fruit so nearly normal that some having had the disease two or three years seem almost as vigorous as unaffected ones, and they bear practically as much fruit as normal trees.

PLYMOUTH, FLORIDA

[18] Hasse, Clara, H. Pseudomonas Citri, the cause of citrus canker. Journ. Agr. Research **4**: 97–100. 1915.

STIPPEN AND SPRAY INJURY

C. H. Crabill and H. E. Thomas

Most pathologists who have expressed an opinion regard apple fruit spot or stippen as a physiological disease involving sap pressure and transpiration. A few have suggested that it may be a form of spray injury. Others attribute it to pathogenic fungi such as *Alternaria* sp. and *Phoma Pomi* (*Cylindrosporium Pomi*).

The various names, stippenflecken, apple fruit spot, Baldwin fruit spot, Jonathan spot, brown spot, and bitter pit have apparently been used to designate the same trouble. At least the written descriptions agree closely. Whether or not they are all the same remains to be seen. With the written descriptions before us and in the present state of our knowledge, it does not seem too radical to assume that they are identical.

For a number of years the so-called fruit spot or stippen of apples has been under observation in Virginia on the varieties Jonathan, Baldwin, Wealthy, Arkansas (Blacktwig) and Grimes. The following descriptive features serve to distinguish it.

The disease appears at, or a short time previous to, ripening time. The spots vary in size from minute depressions in the skin to areas of about one square centimeter. The skin of the affected area is alive, unbroken, more or less strongly depressed and of a deeper color than that over the surrounding healthy tissue. On a red apple the color is deeper red; on a green apple it is deeper green. Beneath the skin is a spherical or lens-shaped mass of brown, dry, corky tissue seldom more than five millimeters in diameter. After ripening begins the cells of this corky tissue are packed with starch grains while in the surrounding healthy cells the starch has largely changed to sugar. The cells of the corky tissue are plainly dead and unaffected by any changes which go on in the healthy pulp. This accounts for the sunken condition of the spots. A large proportion of the spots are found on the blossom half of the fruit.

Fresh razor sections, stained microtome sections, and several hundred isolation tests on various media during three summers have failed to reveal fungi in the affected spots.

It has been suggested that stippen may result from poisoning of cells immediately under stomata or lenticels, particularly at the time when the stomata are splitting to form lenticels and before a protecting layer of cork is formed to close the opening. Following this suggestion the

writers attempted to produce typical fruit spot or stippen by application of spray materials at all periods of development of the apple. The results of these experiments are presented in table 1. The sprays used were arsenate of lead (paste), lime-sulphur solution, bordeaux mixture and copper sulphate.

TABLE 1

Baldwin apples treated with spray mixtures

SERIES	NUMBER OF APPLES AT BEGINNING	NUMBER OF APPLES AT END	SPRAY MATERIAL USED	DATES OF APPLICATION	TYPICAL STIPPEN	EXTERNAL SPRAY INJURY
1	50	29	Arsenate of lead, 9.6 grams per liter	May 29, June 8 and 17	0	
2	50	31	Lime-sulphur 2–50	May 29, June 8 and 17	1	russetting
3	25	20	Lime-sulphur 1½–50	June 8 and 17	1	
4	25	21	Lime-sulphur 3–50	June 8 and 17	0	russetting
5	25	25	Arsenate of lead, 15 grams per liter	June 8 and 17	2	burning
6	25	16	Arsenate of lead, 6 grams per liter	June 8 and 17	1	burning
7	25	11	Lime-sulphur 1½–50	June 17 and 21	0	
8	25	21	Lime-sulphur 2–50	June 17 and 21	0	
9	25	22	Arsenate of lead, 15 grams per liter	June 17 and 21	0	russetting
10	25	23	Arsenate of lead, 6 grams per liter	June 17 and 21	0	
11	25	19	Bordeaux 4–5–50	June 21 and 28, July 6, 14 and 22	2	
12	25	15	$CuSO_4$ 2–50	June 21 and 28, July 6, 14 and 22	0	badly burned
13	50	42	Arsenate of lead, 9.6 grams per liter	June 28, July 6, 14, 22 and 28	5	
14	50	45	Arsenate of lead, 9.6 grams per liter	July 14, 22 and 28	1	
15	50	50	Checks bagged	May 29	4	
16		100	Checks unbagged		4	

The final notes were taken on September 2. After the first treatment the apples in each series were enclosed in glassine bags and remained so the rest of the season, the bags being removed only to make the subse-

quent applications of spray solution. It will be noted that the apples in each series received at least two applications of the spray material while those in series 11 to 13 received five applications. The treatments were so planned as to conform rather closely to the usual spraying schedules practiced by Virginia orchardists. The average size of the apples on the several dates were as follows: May 29, one-half inch; June 8, three-fourths inch; June 17, one inch; June 28, one and one-half inches; July 14, two inches; July 28, two and one-half inches. On July 21, stomata had begun to split to form lenticels, especially on the stem end. This splitting continued rapidly and was most active about July 28.

An examination of the table shows that none of the sprays used produced typical fruit spots, although some of them were strong enough to injure the skin. An occasional spot was found in several of the series but no more than in the checks. In this connection it seems desirable to state that in 1914 the apples on the same trees used in these experiments were badly affected with fruit spot. This same observation has been made in numerous orchards in Frederick County. The summer of 1914 was marked by drouth and a heavy apple crop. Fruit spot was abundant and serious. The season of 1915 has been generally very wet, the apple crop is light and fruit spot is very scarce. From these observations one is forced to conclude that spray treatment has nothing to do with apple fruit spot or stippen.

In several instances apples struck by hailstones when about half grown have exhibited, on ripening, a spot almost identical in appearance with stippen. Except that it is often larger and occurs more often on the stem end of the apple than elsewhere, it is indistinguishable from stippen. Similar spots have been repeatedly found on apples which have hung in such a position as to be blown against stubs of fruit spurs or raised places on the bark of nearby branches. This injury has been reproduced with great fidelity on Baldwin apples by tapping them with a round-faced wooden mallet on July 14 when they were about two inches in diameter. When examined and sectioned on September 3 these spots were found to be very similar to stippen. The brown corky tissue under the skin was filled with starch grains while the healthy cells adjoining held only a small quantity of starch.

In another attempt to produce stippen by artificial means, stigmonose was reproduced so faithfully that Mr. M. B. Waite wrote that there was no doubt about the specimens falling into the general class of stigmonose, although the insect punctures were a little too evident. This was done by injecting apples on July 14 with lime-sulphur solution or with arsenate of lead by means of a hypodermic syringe. The stigmonose thus produced may be described as a slightly depressed, highly colored

area of skin plainly punctured at the center and underlaid by a mass of dry corky tissue similar to that exhibited by stippen.

In view of the results obtained by these tests it seems that stippen or stippen-like spots, i.e., depressed, highly colored areas of skin underlaid by a corky mass of dead, brown cells, may be produced in several ways, viz., by bruising, by insect puncture, by injected poisons, by insufficient water or by any other agent which may kill a few cells before the apple is full grown.

Our results also indicate that stippen is almost certainly not caused by spray materials as they are commonly applied.

BLACKSBURG, VIRGINIA

INTERNATIONAL PHYTOPATHOLOGY[1]

OTTO APPEL

"Phytopathological problems are no longer local problems, but world problems, and the sooner we recognize and adopt this point of view, the sooner we shall be able to successfully attack them."—C. L. Shear, in Phytopathology **3**: 84. 1913.

To speak of international matters at a time like the present seems purposeless, both because of the fact that between many countries cooperative work will be well-nigh impossible for years to come, and because of the destruction, over a wide field, of the fundamental principle of science—the belief in objectiveness and love of truth.

On the other hand there are still many countries in which the inclination toward cooperative work has not diminished, and for the others also the time will pass in which it is difficult for them to work together. Therefore it seems to me appropriate to hold to the thought of further cooperation, and to contribute as much as possible to the promotion of this object.

The necessity for cooperative work among investigators of all countries is generally recognized, and all who have learned to look upon the various plant diseases from an extended viewpoint will with conviction subscribe to Shear's words quoted above.

Not quite so distinct as the necessity for this work is the course to be followed in order to attain the end desired with the least expenditure of time and labor. This is probably due mainly to the fact that each one desires to follow the line which is most familiar to him, and is prone to assume that in this way the most important phase of the question is to be met. One, therefore, desires the establishment of special laboratories; another thinks that far-reaching legislative measures will further the object; some lay stress upon statistical methods, while others again would prefer to see the matter treated in a purely scientific manner, and to leave its application in practice to others. Finally, there are those who regard as superfluous all scientific investigations having no direct bearing on the question under consideration.

There is besides, another difference in the understanding of phytopathology, which can probably be explained by reason of the particular train-

[1] Read at the special meeting of the American Phytopathological Society, Berkeley, Calif., August 3, 1915.

ing of the individual investigator. The mycologist is likely to place the greatest emphasis upon the study of fungi; the plant physiologist, in accordance with his special line of investigation, will consider chiefly questions of nutrition, since plant physiology regards of foremost importance the vegetative processes and metabolism. The morphologist and ecologist will treat many pathological questions from the viewpoint of his specialty. The breeder by reason of his experience will be likely to consider all questions from the standpoint of breeding resistant sorts. The phytopathologist finally, with a preliminary knowledge of agriculture, will pay special attention to the dependence upon economic conditions.

This brief survey shows the diversity of phytopathology, and it is well known that in all these directions numerous works have already appeared and that the scientists of all countries, wherever engaged in scientific work, are participating in it. These have drawn not only upon their own personal experiences, but have worked also under the most varied outside conditions, and thus our science already stands upon an international basis.

So long as phytopathology was still an unexplored field, each one, wherever located, could work according to his inclination and realize that he was rendering service, and even to this day such work can not be dispensed with. In connection with it, however, there has developed the necessity of taking up all phases of important questions and to bring them to a comprehensive solution. The individual can accomplish this only as he is given the opportunity to extend his investigations over a wider field, either independently or through the assistance of the specialists and coworkers in various countries.

Let us take an example of this sort; to me the Fusarium problem naturally suggests itself in this connection. It is not long ago that the fungi of the genus Fusarium were regarded as unimportant, and so it happens, for instance in von Tubeuf's Handbook, that only a few lines are devoted to this genus. From various sources attention was then called to the fact that under certain conditions these fungi are of great significance, and it was brought to mind that earlier there existed at least a suspicion of the pathogenicity of species in this genus. The main difficulty in the way of progress lay in the fact that taxonomy was absolutely insufficient and that therefore it was frequently impossible to prove what species the various authors had before them. In order to remove this primary evil I undertook the preparation of various monographs on diseases, but with the first one submitted, by Schikorra,[2] I realized that this was not

[2] Appel, O. Beiträge für Kenntniss der Fusarien und der von ihnen hervorgerufenen Pflanzenkrankheiten. 1. Schikorra, G. Fusarium Krankheiten der Leguminosen. Arb. k. Biolog. Anst. Land- und Forstw. **5**, no. 4. 1906.

the proper way. With Wollenweber I then undertook the preparation of the foundation for a monograph on the genus Fusarium.[3] A further very necessary work is a comprehensive monograph. On account of my position I am not able to devote the necessary time to the consideration of this individual study, and I have left the further elaboration to Wollenweber, who, thanks to the assistance of the U. S. Department of Agriculture, with which he has been associated for several years, has carried on the required work both here and in Europe, so that in the near future a good monograph seems assured.[4]

This work, from the standpoint of the pathologist, is only preliminary, and, strictly speaking, does not belong in the realm of phytopathology. But it has been shown, on this as well as on other occasions, that for the purposes of pathology many systematic questions require a greater elaboration than is needed for purely taxonomic purposes. Above everything, taxonomy must be extended to take in biological viewpoints. For this reason the phytopathologist must also undertake to work out such questions. However, just as the writer of a monograph on phanerogams can not bring it to a successful conclusion without consulting the herbaria of Kew, Paris, Berlin, and other places, so the writer of a monograph on the larger groups of fungi is compelled to examine original material in herbaria and collections, or in other words, either to communicate with investigators of other countries, or better still, to avail himself of these means of assistance right on the spot. That means, of course, that the special investigator must undertake research journeys, which form an essential feature of the individual work, and which in ultimate purpose and range are intimately connected with this work.

For newly described or verified species a further means of assistance is the "Centralstelle für Pilzkulturen" of the International Botanical Society, which is a branch of the Phytopathological Institute, Willie Commelin Scholten in Amsterdam under the direction of Dr. Johanna Westerdijk. The advancement of this Station is also doubtless in the interest of international phytopathology, as Shear has already indicated. It should therefore be the duty of every investigator to send to this institution cultures of the fungi investigated by him, since living material, of course, is always of more value than dead material. In addition to this,

[3] Appel, O. und Wollenweber, H. W. Grundlagen einer Monographie der Gattung Fusarium. Arb. k. Biolog. Anst. Land- und Forstw. **8**: 1–207. 1910.

[4] It may be of interest to state that Dr. Wollenweber, who, at the outbreak of the war, joined the German Army, has now been granted a furlough for the purpose of continuing his studies, and that every facility for this purpose has been placed at his disposal by the Imperial Biological Laboratory in Dahlem.

however, it would be of advantage to distribute authentic herbarium material to the larger herbaria.

To go back to our example, we find that there are two types of Fusarium diseases, vascular mycosis and local tissue destruction. Each apparently has a somewhat different distribution. How far this distribution is connected with climatic and soil conditions has not been sufficiently worked out, although the fact that vascular fusarioses are particularly frequent in the warmer parts of America, as well as the statement of Jones[5] that the Fusarium of the cabbage-wilt disease is not able to infect except at a soil temperature above 17°C., would point to climatic influence.

All experiments intended to explain outward influences in the appearance of fungous diseases are for practical purposes not conducted in any one locality, since frequently only through widely diversified conditions the really authoritative factors are disclosed. This is also true of breeding resistant sorts. So long as we do not know the factors that cause resistance,[6] proof as to whether a kind is generally resistant or only in certain localities, can be obtained only by the cultivation under the most varied conditions.

Another viewpoint of importance to the question of resistance has been brought out by the work of Barrus.[7] As is well known, Barrus has proved that the resistance of various kinds of beans against *Glocosporium lindemuthianum* differs with various strains of fungus. It is, of course, possible to isolate various strains or to send for them for the purpose of experimentation, but here again it becomes an international matter as soon as the work attains universal significance.

In many other details certain problems can only be solved by investigations carried on in widely separated localities. Therefore I will note a few examples. The biology of *Phytophthora infestans* has been set forth in the classic work of DeBary,[8] but he did not succeed in solving the question of oospore formation. Others also, working on the problem in Europe, have not been successful. In America, on the other hand, this problem has recently been solved.[9] Whether this was due to the different

[5] Verbal statement of L. R. Jones.

[6] Appel, O. Disease resistance in plants. Science, **41:** 773–782. May, 1915.

[7] Barrus, M. F. Variation of varieties of beans in their susceptibility to anthracnose. Phytopath. **1:** 190–195. 1911.

[8] DeBary, A. Die gegenwärtig herrschende Kartoffelkrankheit, ihre Ursache und ihre Verhütung. Leipzig, 1861.

[9] Clinton, G. P. Oospores of potato blight, Phytophthora infestans. Rept. Connecticut Agr. Exp. Sta. **1909–1910:** 753–774. 1910. Jones, L. R. Investigations of the potato fungus, Phytophthora infestans. Vermont Agr. Exp. Sta. Bul. 168, and others.

methods of work here, or whether oospore formation more readily takes place in America, has not been fully determined.

The rust problem also shows progress due to the extension of experiments into other countries. Gassner[10] during his activities in Montevideo made it a point to study the conditions of teleutospore formation. The complete manner in which he was able to accomplish this would not have been possible in Europe, for only in the subtropics are the conditions favorable for a continuous sowing of grain throughout the entire year.

Proof of the importance of another kind of cooperation was shown recently in the Department of Agriculture by a conference called to consider the white pine blister rust. From the reports of the American delegates on the one hand, and those of Kølpin Ravn and the writer on the other, it was plainly shown that the problem in the United States and in Denmark and Germany presented entirely different aspects, a fact which to my knowledge has nowhere been brought out clearly in the literature on the subject.

Here it is plainly indicated how necessary it is to have discussions by the representatives of the various countries in order to interpret the problem from all sides. It goes without saying that this again will influence the handling of the problem in the various countries. This is especially the case when legal measures against certain diseases are introduced. On account of ignorance of the conditions prevailing in other countries a certain severity is likely to result, causing an unnecessary interference with trade. This applies in both directions. A disease may occur in one country and possess absolutely no significance, while for another country it may be of importance, or become so. In such cases one side alone can not determine what measures may be the right ones, and only a knowledge of all conditions can lead to a just regulation, applicable to both sides. Such knowledge is best gained by means of research journeys. While the travels referred to above serve particularly in the interest of individual problems, they are also of general importance. In each country there should be certain phytopathologists who are familiar with the conditions in other countries. Such knowledge, however, is not attained by a short visit to the country in question. It is necessary, in addition, to enter into close relation with as many colleagues in that country as possible, and by means of a free exchange of opinions and the inspection of numerous typical conditions, to gain as comprehensive knowledge as possible.

This viewpoint was the determining factor when the invitation to visit this country came to me in 1914, and to Kølpin Ravn in 1915, and I think

[10] Gassner, G. Die Teleutosporenbildung der Getreideplize und ihre Bedingungen. Zeitschr. f. Botanik, **7**, no. 2. 1915.

I can assert for us both that the manner in which we have been received here fully answered the purpose intended.

In my opinion the most important phase of such visits is the formation of close personal relations, for only by means of such can it be expected that the insight into strange conditions may reach a degree commensurate with the purpose in view. When such close contact has once been established, it will also become easier to apply to countries other than their own the experiences of the several investigators in certain branches. There are still a number of problems which in one country may be considered as solved, while in another this is not the case.

Such, for example, is the smut problem. You know that we in Europe generally regard the question of smut control as solved.[11] Here and there smut may still occur, even more extended outbreaks are not impossible, but in general the statement may be said to apply there, that "Each one has as much smut as he deserves."[12] That is to say, that by the proper application of the methods of control a more extended occurrence of smut may be prevented. We have preventive measures against the smuts which infect seedlings as well as flowers, and in addition, apparatus has been constructed which makes it possible to apply these remedies even on a large scale. In America, on the other hand, the smut problem does not seem to have been solved, at least the occurrence of smut in many localities is so pronounced that I was forced to that conclusion. Climatic, and above all, cultural conditions, seem to play an important part in this connection.

The solution may be arrived at by studying the conditions in a country in which the smut problem has been solved and by applying the measures adopted there to the conditions in this country, or by instructing a phytopathologist especially familiar with these questions to undertake a study of the conditions here. In the first instance, a colleague visiting Europe may be assured that he would receive all the assistance possible. The other way is possibly more difficult on account of the hesitancy in designating a stranger to undertake the solution of a problem. It is, however, the most certain and the shortest way, because one who has worked for years in one branch has at his command not only the experience shown by established methods of procedure, but also those obtained in the course of his investigations. This enables him, more readily than any one else, to recognize the salient features in which the conditions of both countries

[11] Eriksson, J. International phytopathologic collaboration. Phytopath. **5**: 133–138. 1915.

[12] Appel, O. Bekämpfung des Getreidebrandes. Flugschrift der Deutschen Landwirtschafts-Gesellschaft, no. 8, p. 6.

differ, and upon which must depend the modification of remedial measures. Finally, it is immaterial who promotes a cause, so long as it is promoted.[13]

I mentioned smut as an example, as it is a question to which I have given special attention. There are, of course, also cases of which the reverse may be said, and such instances may constantly recur.

International relations may also be materially advanced by regular or occasional conferences. Personally I prefer informal conferences. For large international conferences it is impossible to avoid making up a program long in advance of the meeting. The statements which are then made always bear a more or less official character, and frequently do not contain more than a conscientious study of the literature on the subject would disclose. It is, of course, true that there are associated with these more intimate discussions, which by many are regarded as the more important part of conferences or meetings. Such conferences, however, can not be called frequently on account of the great expense, and more intimate discussions may also be had in other ways.

Thus it was agreed, in connection with the meeting of International Botanists, which was to have taken place in London in May, 1915, that the phytopathologists present were to meet informally for the purpose of freely discussing important questions. This agreement extended to American, German, and Dutch phytopathologists; each one was to make further propaganda, and since it was expected that a number of coworkers from other countries would take part in the Congress of Botanists, it was hoped that many countries would have been represented. Similar opportunities often occur, they only need to be utilized. Also, when a phytopathologist visits other countries he should be asked to participate in discussions of all kinds. I have learned the value of this myself, since I had the opportunity to be present at discussions in the U. S. Department of Agriculture as well as at meetings of other kinds. On the other hand, for example, Whetzel took part in Dahlem in the discussion of the potato question,[14] and in recent years meetings have frequently taken place between German, Austro-Hungarian, and Dutch phytopathologists, which have been recognized as so advantageous that it was intended to extend them as much as possible, and to supplement them with general inspections.

However, I wish by no means to designate the formal international conferences as undesirable; they are doubtless of value, and are especially indispensable in bringing about international agreement, but aside from

[13] Appel, O. Die Organisation des Pflanzenschutzes in Deutschland. Arbeiten der Deutschen Landwirtschafts-Gesellschaft, 1914.

[14] Vorschläge zur Untersuchung von Kartoffelmustern hinsichtlich ihres Gesundheitszustandes und ihrer Bewertung als Pflanz- und Speise-Kartoffel. Jahresber. Ver. angewandte Botanik **10:** 12. 1912.

this, it should be the aim to have phytopathologists meet as frequently as possible, for the closer they come into personal contact the more advantageous will it be for international work. I would like to add a few words in regard to the plan for many years recommended by Eriksson, namely, the establishment of international special institutions. Eriksson proposed the establishment of institutions devoted particularly to the investigation of diseases of grain, of diseases of potatoes, beets, and similar crops, also of the grape-vine and fruit-tree diseases, and to locate them in such a manner that on the one hand they would be situated in the largest producing centers of these various groups of plants, and on the other hand, to distribute them also among the principal countries of Europe. These institutions were to be erected and maintained at common expense, and a specially equipped investigator was to be at the head of each and by independent research to serve the purpose in view. In Europe there is now no prospect of the establishment of such institutions. It would seem to me that the end in view may also be reached by other means.

In the event of the appearance in any one country of diseases of a cultivated plant, it is the duty of that country to employ every available means to avoid widespread injury to its agriculture. The scientific investigation of the disease is doubtless to be included in these means. To begin with, an attempt will be made to have such cases investigated by existing institutions, and if the current means are insufficient for that purpose, special sums will doubtless be appropriated. This is already the case. For years special sums have been set aside for the use of the Imperial Biological Institute in Berlin-Dahlem for investigations in smut control and beet and potato diseases, making comprehensive work possible. If, however, the existing institutions on account of their location or equipment are not in position to carry such work to a successful completion, the country in question will in self-interest establish special institutions for temporary or permanent investigations, and either attach these to existing establishments, or place them upon an independent footing. The formation of commissions to bring about cooperation among various institutions is another method which has been frequently undertaken. As examples of this may be mentioned the Laboratory for the Investigation of Grape Vine Diseases in Metz, a branch of the Imperial Biological Institute in Berlin-Dahlem; the Institute for Potato Diseases at Greeley, Colorado, under the direction of the U. S. Department of Agriculture; the Austrian Commission for the Investigation of Potato Diseases (especially the leaf-roll disease); the Pennsylvania Chestnut Tree Blight Commission.

If several countries have the same interests, each one must devote itself to the problem, but in addition, cooperative work should also become

possible, especially when the much desired personal relations exist between fellow workers. This also has occurred at the present time. I refer, for instance, to the cooperative work between Germany and France in connection with phylloxera,[15] and to the cooperation between Germany, Austria-Hungary, and Holland in the question of potato diseases.

A further advancement of such cooperative work may be brought about also by the exchange between various countries of experienced investigators or assistants. It has already become possible for individual phytopathologists to work in other countries, in university institutes or in special institutions. It would not be a difficult matter to have these individual cases take the form of an exchange. The phytopathologists in question would then take the place of those to be exchanged, and when they returned with added experience they might be reinstated in their old positions. The entire cost to be defrayed would be confined to that of necessary travel, a sum which in the light of the benefit to be gained would be insignificant.

Another advantage to be derived would be the fact that the utilization of the foreign literature would be extended; this use is now frequently hampered because of insufficient knowledge of the language and insufficient insight into the conditions of other countries.

You see, gentlemen, that I place the greatest weight upon the development of personal relations. When these have once sufficiently advanced, then the other questions, such as that presented by Shear, the establishment of an international association and a general organ for reference, will develop of themselves. Furthermore, the indispensable international conference and international legislation will then display greater unity of purpose than has been the case heretofore.

BERLIN-DAHLEM, GERMANY

[15] Börner, Jahresb. k. Biolog. Anst. Land- und Forstw. **9**:—. 1914.

IDENTITY OF PERIDERMIUM MONTANUM WITH PERIDERMIUM ACICOLUM

GEORGE GRANT HEDGCOCK

The occurrence of *Peridermium montanum* Arthur and Kern on the lodgepole pine, *Pinus contorta* Loud. (*Pinus murrayana* Oreg. Com.) in Montana[1] and its probable relationship to a species of Coleosporium found on species of Aster in the same region has already been noted by the writer.

In July, 1914, specimens of *Peridermium montanum* on *Pinus contorta*, collected by Forest Assistant West in the Gallatin National Forest near Bozeman, Montana, were received by the writer from Acting Forest Supervisor A. H. Abbott. Inoculations were made by the writer on July 7, 1914, in the Pathological Greenhouses at Washington, D. C., on plants of the following species, control plants of each species being set aside to check the results: *Aster conspicuus* Lindl., *Coreopsis verticillata* L., *Elephantopus tomentosus* L., *Helianthus divaricatus* L., *Solidago canadensis* L., *S. multiradiata* Ait., and *Vernonia glauca* (L.) Britton.

On July 22, 1914, the uredinia of a species of Coleosporium appeared on the leaves of two plants of *Aster conspicuus*, and on August 23, 1914, the telia were found present. None of the remaining inoculated plants became infected, and all the control plants remained free from the rust. The species of Coleosporium obtained on *Aster conspicuus* closely resembles *Coleosporium solidaginis* (Schw.) Thüm. in its morphology and is now assigned by the writer to this species. This is proof that *Peridermium montanum* is the aecial stage of *Coleosporium solidaginis* as known in the Northwest. From this it follows that *Peridermium montanum* Arthur and Kern is identical with *Peridermium acicolum* Underwood and Earle which has hitherto been known as the aecial form of *Coleosporium solidaginis* in the eastern United States.

Arthur and Kern,[2] however, consider *Peridermium montanum* distinct from *Peridermium acicolum* and note differences in the length and in the

[1] Hedgcock, G. G. Notes on some western Uredineae which attack forest trees. Mycologia **4**: 144–145. 1912.

Notes on some western Uredineae which attack forest trees. II. Phytopath. **3**: 16–17. 1913.

[2] Arthur, J. C., and Kern, F. D. North American species of Peridermium on pine. Mycologia **6**: 117. 1914.

walls of the aeciospores, which may or may not finally hold as specific. Unless greater differences than have been found by the writer can be distinguished between the eastern and western forms of *Coleosporium solidaginis*, there are not sufficient reasons in his opinion for making a separate species of these western forms. The spore variations here are no greater than exist between the aeciospores of the western form of *Peridermium pyriforme* Peck (*Peridermium bethelii* Hedgc. and Long) on *Pinus contorta murrayana*, and those of the eastern form of this Peridermium on *Pinus divaricata* (Ait.) Du Mont de Cours, yet these forms are considered as one species.

Peridermium montanum, now recognized by the writer as the western form of *P. acicolum*, has been found in the United States as follows:

MONTANA

On *Pinus contorta* (*P. murrayana*)—Gallatin National Forest, Middle Creek, *Stuart*, F. P.[3] 2990; *George*, F. P. 11181; *H. E. West*, F. P. 15552; South Douglas Creek, *H. E. West*, F. P. 15553; Rimini, *F. D. Kelsey* (type of species, Herb. N. Y. Bot. Gard.).[4]

In the Dominion of Canada, *Peridermium montanum* has been found as follows:

ALBERTA

On *Pinus contorta* Loud. (*P. murrayana*)—Banff, E. W. D. *Holway* (Fungi Columb. 2541); Rocky Mountains, *Macoun* (Ellis Collection 573, Herb. N. Y. Bot. Gard.).

These data do not, however, greatly extend the previously known range of the aecial stage of the fungus. Arthur and Kern[2] previously reported its range as follows:

On *Pinus murrayana* Oreg. Com. Montana (Blankinship, Stuart); Washington (Suksdorf 302 & 645); Alberta (Holway); Rocky Mountains, Canada? (Macoun).
On *Pinus scopulorum* (Engelm.) Lemm.,[4] Montana (Kelsey).

Coleosporium solidaginis, the uredinial and telial stages of the fungus, has a wider known range than the aecial or Peridermium stage. The Western form of the Colesporium has been found in the following States:

[3] F. P. = Forest Pathology Investigations number.

[4] Dr. P. A. Rydberg and the writer have examined this collection and find that the host species is *Pinus contorta* (*P. murrayana*) and not *P. scopulorum* (Engelm.) Lemm. This renders doubtful the occurrence of the fungus on the latter species of pine, since no other occurrence has been reported.

CALIFORNIA

On *Aster chilensis* Nees (*A. chamissonis* A. Gray)—San Francisco, *M. A. Howe* (46, Fungi of California); Palo Alto, *C. F. Baker* (1713), Plants of the Pacific Slope).

On *Aster laevis geyeri* A. Gray—Mineral, *Long*, F. P. 17851.

On *Aster radulinus* A. Gray—Berkeley, *W. C. Blasdale* (Herb. N. Y. Bot. Gard.).

On *Solidago californica* Nutt.—San Francisco, *M. A. Howe* (46 Fungi of California).

On *Solidago confinis* A. Gray—Pasadena, *A. J. McClatchie* (Herb. N. Y. Bot. Gard.); San Bernardino Mts., *S. B. Parrish* (5311, Plants of Southern California).

COLORADO

On *Aster hesperius* A. Gray—Steamboat Springs, *Hedgcock*, F. P. 3883.

On *Aster laevis geyeri* A. Gray—Steamboat Springs, *Hedgcock*, F. P. 3885.

On *Aster lindleyanus* T. & G.—(Locality not given).[5]

On *Solidago oreophila* Rydb.—Tolland, *E. Bethel* (405, 2382); *Hedgcock*, F. P. 15886; Boulder, *Hedgcock*, F. P. 15864.

IDAHO

On *Aster adscendens* Lindl.—Trinity, *J. F. Macbride* (533, Plants of Idaho).

On *Aster conspicuus* Lindl.—Lake Pend Oreille, *L. F. Henderson* (4337, Ellis Collection, Herb. N. Y. Bot. Gard.); St. Maries, *Hedgdock & Weir*, F. P. 11107; Priest River, *Hedgcock & Weir*, F. P. 9494.

On *Aster salicifolius* Lam.—Caldwell, *E. Bartholomew* (802, 4011, Fungi Columb.).

On *Aster laevis geyeri* A. Gray—Castle Creek, *Hedgcock*, F. P. 9595; Priest River, *Hedgcock & Weir*, F. P. 9488; St. Maries, *Hedgcock*, F. P. 9524.

MONTANA

On *Aster conspicuus* Lindl.—Bozeman, *F. D. Kelsey* ($\frac{9}{5}\frac{2}{6}$, Herb. N. Y. Bot. Gard.); *E. T. & E. Bartholomew* (4112, Fungi Columb.); *Hedgcock*, F. P. 11173 and 11175); Monarch, *Hedgcock & Weir*, F. P. 11126; Red Lodge, *Hedgcock*, F. P. 11163; Thompson Falls, *Hedgcock & Weir*, F. P. 9446 and 9446a.

On *Aster eatoni* (A. Gray) Howell—Camp Geduhn, Lake MacDonald, *Hedgcock & Weir*, F. P. 11075; Locality not given.[5]

On *Aster foliaceus* Lindl.—Sand Coulee, *F. W. Anderson* (99, Parasitic Fungi of Montana).

On *Aster laevis geyeri* A. Gray—Summit, *Hedgcock*, F. P. 11109; Bozeman, *Hedgcock*, F. P. 11174.

[5] Arthur, J. C. Uredinales. No. Amer. Flora **7**, pt. 2: 91–92. 1907.

On *Solidago canadensis* L.—Silesia, *E. T. & E. Bartholomew* (4313, Fungi Columb.).

On *Solidago glaberrima* Martens—Locality not given.[5]

On *Solidago missouriensis* Nutt.—South Douglas Creek, *Hedgcock*, Helena, *F. D. Kelsey* ($\frac{8}{7}\frac{8}{8}$); Butte, *F. D. Kelsey* (Herb.) N. Y. Bot. Gard.

WASHINGTON

On *Aster eatoni* (A. Gray) Howell—Seattle, *C. V. Piper* (64, Wash. Flora).

The Coleosporium stage of this rust has also been found in the Dominion of Canada as follows:

BRITISH COLUMBIA

On *Aster occidentalis* Nutt.—Locality not given.[5]

On *Solidago multiradiata scopulorum* A. Gray—Locality not given.[5]

From the preceding data on known distribution[6] it will be seen that the present known range of the aecial stage of the fungus as represented by the Peridermium in the United States is confined to the State of Montana; and in the Dominion of Canada to Alberta, while the western range of the uredinial and telial forms of the fungus as represented by *Coleosporium solidaginis* is much more extensive, having been found in the States of California, Colorado, Idaho, Montana, and Washington in the United States; and in British Columbia and Alberta in the Dominion of Canada.

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[6] The writer has examined all the specimens cited except those credited to Arthur's Uredinales.

INOCULATION EXPERIMENTS WITH PERIDERMIUM MONTANUM

JAMES R. WEIR AND ERNEST E. HUBERT

A form of leaf Peridermium, which has previously been reported from Montana as *Peridermium montanum* Arthur and Kern by Arthur and Kern (1906, 1914)[1] and by Hedgcock (1912, 1913)[2] was found by the writers, May 13, 1915, on the lodgepole pine, *Pinus contorta* Loud., near the Savenac Nursery of the U. S. Forest Service at Haugan, Montana. The aeciospores of this Peridermium taken from the needles of the lodgepole pine were sown upon *Solidago canadensis* L., *S. missouriensis* Nutt., *Aster laevis geyeri* Gray, *A. hesperius* Gray, *Arnica cordifolia* Hook., and *Castilleja miniata* Dougl. in the greenhouse at Missoula and at the field camp in Idaho, under control conditions, with the results shown in table 1.

On June 14, the following observations were made at the Savenac Nursery:

Case No. 1. A small seedling of lodgepole pine with its lower branches heavily infected with the needle Peridermium was found growing along the eastern border of the nursery beds. Surrounding this tree and just beneath the lower branches were several plants of *Solidago canadensis* L. The leaves of the Solidago were covered with the sori of *Coleosporium solidaginis* (Schw.) Thüm. The plants farther away bore but few sori and some bore none at all.

Case No. 2. Two larger trees about ten or twelve years old had a heavy infection of Peridermium on the needles of the lower branches. Just beneath these branches were plants of *Aster laevis geyeri* Gray and *Solidago canadensis* L., both having the Coleosporium in abundance on their leaves. The infection by the Coleosporium diminished on the Asters and Solidagos as the distance from the trees increased, the heaviest infections occurring on the plants situated immediately beneath the lower branches of the lodgepole pines. Castilleja plants in close proximity to the trees were normal and free from infection.

[1] Arthur, J. C., and Kern, F. D. North American species of Peridermium. Bul. Torrey Bot. Club **33**: 403–438. 1906. North American species of Peridermium on pine. Mycologia **6**: 109–138. 1914.

[2] Hedgcock, Geo. G. Notes on some western Uredineae which attack forest trees. Mycologia **4**: 140–147. 1912. Notes on some western Uredineae which attack forest trees. II. Phytopath. **3**: 15–17. 1913.

Cases Nos. 3, 4, and 5. Three isolated seedlings of lodgepole pine had their lower branches infected with the Peridermium. In all three cases *Solidago canadensis* L. and *S. missouriensis* Nutt. growing within a radius of two feet of the trees were heavily infected with the Coleosporium. Plants farther away were slightly infected and some not at all.

Case No. 6. An isolated seedling of lodgepole pine had most of the needles of the crown infected with the Peridermium. Just beneath the lower branches a group of *Castilleja miniata* was found growing in normal health. No trace of infection could be found on the leaves. Within a

TABLE 1

*Inoculation data for Peridermium montanum on needles of Pinus contorta**

NUMBER OF PLANTS INOCULATED	NUMBER OF PLANTS NOT INOCULATED; FOR CONTROL PURPOSES	HOST LOCALITY	SPECIES INOCULATED AND METHOD OF INOCULATION	DATE OF INOCULATION. *1915*	UREDINIA	TELIA	DEGREE OF INFECTION
2	1	Savenac Nursery, Haugan, Mont.....	*Arnica cordifolia* (dusted)	May 17	No result		0
1	1	Savenac Nursery, Haugan, Mont.....	*Arnica cordifolia* (wounded)	May 20	No result		0
1	1	Savenac Nursery, Haugan, Mont.....	*Castilleja miniata* (wounded)	June 3	No result		0
2	1	Savenac Nursery, Haugan, Mont.....	*Castilleja miniata* (wounded)	June 3	No result		0
2	1	Savenac Nursery, Haugan, Mont.....	*Solidago canadensis* (wounded)	June 16	1 plant July 19		Slight
1	1	Savenac Nursery, Haugan, Mont.....	*Aster laevis geyeri* (dusted)	June 16	No result		0
2	2	Savenac Nursery, Haugan, Mont.....	*Aster laevis geyeri* (dusted)	May 22	2 plants June 14		Medium
2	2	Savenac Nursery, Haugan, Mont.....	*Solidago missouriensis* (dusted)	May 22	2 plants June 14		Medium

* All plants covered by paper bags to isolate.

radius of one and a half feet several plants of *Aster laevis geyeri* Gray and *Solidago canadensis* L. had their leaves covered with eruptions of *Coleosporium solidaginis.* The infection on these plants diminished in direct proportion to the distance away from the lodgepole pine.

Field and greenhouse inoculation experiments performed upon three Aster and four Solidago plants with the aeciospores of *Peridermium montanum* from the lodgepole pine needles developed the characteristic and identical Coleosporium found upon similar plants cited above. The

inoculations made upon the three plants of *Castilleja miniata* showed negative results.

These experiments and observations prove the alternate hosts of this Peridermium to be species of Aster and Solidago, as far as aster is concerned confirming the suggestion of Hedgcock (1912). For the first time successful inoculations are here reported on species of Solidago. The rust produced is that heretofore known as *Coleosporium solidaginis* (Schw.) Thüm., developing as the alternate stage.

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A STUDY OF THE BROWN ROT FUNGUS IN NORTHERN VERMONT

H. E. Bartram

Persoon (1) in 1796 gave the name *Torula fructigena* to a fungus which he found on the decayed fruit of *Prunus domestica, Amygdalus persica* and Pyrus; but in 1801 he changed its name to *Monilia fructigena.* In 1851, Bonorden (2) described *Monilia cinerea* as the cause of small gray, sometimes brownish, conidial tufts on fruit. *Monilia cinerea* and *M. fructigena* have been widely confused but Saccardo in 1886 recognized both of them. Woronin (3) made a careful study of the two species and arrived at the conclusion that there could be no doubt that there were two species, one attacking principally stone-fruits and the other more prevalent on pomes. In 1904, Aderhold (4) confirmed Woronin's conclusion from work based on measurements of the asci and ascospores of both species.

The ascomycetous nature of these two species of Monilia was surmised by Schröter (5) in 1893, and he placed them in the genus Sclerotinia as *Sclerotinia fructigena* and *S. cinerea.* The peziza cups of the ascomycetous stage of one of these fungi were discovered in 1902 by Norton (6) who first noticed them on the ground of an old peach orchard in Maryland. To the fungus which he found on the mummied stone fruits Norton gave the name of *Sclerotinia fructigena,* and this is the title by which it is still commonly known in the United States.

The difficulty in differentiating between *Sclerotinia fructigena* and *S. cinerea* is accentuated by the fact that the species from the stone-fruit can be readily carried over to the apple or pear, and vice versa. The following are the more important points of divergence as worked out by Woronin (3), Aderhold (4) and others:

1. The conidia of *S. fructigena* always are larger than those of *S. cinerea.*

2. The conidial tufts of the former either are a clear brownish yellow or ochre and large, while those of the latter are ash-gray and small.

3. There is a difference in the shape of the conidia, those of the *S. fructigena* having an elongated ellipsoidal form, while those of the *S. cinerea* are more rounded, although they are somewhat lemon-shaped in both species.

4. *S. fructigena* occurs in nature on pome fruits while *S. cinerea* attacks stone-fruits such as plums, cherries and peaches.

5. Between the conidia of the former species are disjunctors, while in the case of the latter none are present, and the conidia separate by a tearing apart of the tissue of the walls.

6. The ascospores of *S. fructigena* are pointed sharply at the ends, while those of *S. cinerea* are rounded.

7. The ascospores and asci of the former always are larger than those of the latter.

During the last few years some valuable additions to our knowledge of these two fungi have been made by Ewert (7), Matheny (8), Conel (9), Reade (10), Pollock (11), and Jehle (12). Ewert's special contribution was his demonstration of the fact that *S. fructigena* and *S. cinerea* differ materially in their ability to pass successfully through the winter. The color of the conidial tufts on the fruit were used as a means of recognition, yellow for those of *S. fructigena* and gray for *S. cinerea*. In addition to the exposure of the conidia to outdoor winter temperatures, some were subjected to artificial cold as low as −20°C. (−4° F.). The exposed conidia were then used to infect susceptible host plants. The experiments were conducted for two winters at Proskau, Germany. That of 1909–1910 was very mild, but that of 1910–1911 was much colder and, during a cold period between February 7 and February 16 the thermometer registered from −7 to −21.7°C. Ewert's conclusions were that the spores of *S. cinerea* are able to live over winter in Proskau on sweet and sour cherry mummies as well as on those of plums and still be capable of producing infection in the spring, while the spores of *S. fructigena* usually lose their ability to germinate at the beginning of the winter whether occurring on pomes or on stone-fruits such as the plum.

Matheny (8) and Jehle (12) from comparative studies of material from Europe and this country have concluded that there are two species but that the common one in the United States is *S. cinerea*. The work of Matheny is very complete and is based on fruit inoculations, characters in pure culture and numerous measurements of asci, ascospores and conidia from various sources.

Reade (10) finds only one species common in New York, but the asci and ascospores produced by it are larger than those of *S. cinerea* and also than those the measurements of which were given by Norton. He considers it, therefore, to be *S. fructigena* as the dimensions agree fairly well with the size given by Aderhold (4) for that species.

Pollock (11), from measurements of conidia found at Ann Arbor, Michigan, and a few measurements of asci and ascospores from plums and peaches from two localities in Michigan, finds only one species but this with smaller asci, ascospores and conidia than those of *S. fructigena*, although not as small as those given by European investigators for *S. cinerea*.

Conel (9) found the average size of the conidia from all sources (mummied fruits and pure cultures) to be 13.3 by 7.6μ, which, while it is smaller than the average size given by Matheny, is nearer to those of *S. cinerea* than to those of *S. fructigena*. While his data on the vitality of the conidia over winter are not always consistent, he was able to show that in the latitude of Urbana, Illinois, conidia may survive the winter.

OBSERVATIONS IN VERMONT

The two winters chosen for these observations could not have been better in respect to contrast in temperature conditions. The winter of 1912–1913 was generally considered to be as mild as any that has occurred in recent years, while that of 1913–1914 was exceedingly severe. The periods of cold weather in the former winter were brief and not numerous and at no time did the official temperature at Burlington go below −24°C. During the latter season the cold was almost continuous with some long periods of below zero weather and at times a minimum temperature of −33°C. was reached. Thus an opportunity was presented of contrasting in one locality very divergent weather conditions.

Exposure of conidia to cold. Some plum trees in a garden at Winooski, Vermont, furnished an abundance of material for the work during the winter of 1912–1913. Tests of the conidia from these fruits made in hanging drop cultures in the laboratory in early November showed abundant germination.

Mummied fruits hang on their pedicels in spite of severe storms, but in order to insure some of them against falling off, a few choice clusters of dry, infected fruits were enclosed in coarse cheese cloth sacks tied to the branches. The cloth was thin enough to permit the free passage of air and moisture to the plums.

The winter of 1912–1913 was unusually mild, but on February 9, the temperature remained for 18 hours below −18°C. and at one time reached the minimum for the winter, −24°C. The conidia were brought into the laboratory from time to time and germination tests made. Results of these tests are shown in table 1.

Pure cultures of the fungus were made from the local plums, and these cultures, together with pure cultures secured from the New Jersey Agricultural Experiment Station were exposed during the winter in an open barn. So far as could be observed there were no differences in the germination of the conidia left on the plums hanging on the tree and those exposed to the cold in the form of pure cultures. Similar trials with pure cultures were made again during the winter of 1913–1914.

Inoculations of buds and flowers. Twigs of plum and cherry bearing both leaf and flower buds were brought into the laboratory on April 20

TABLE 1

Germination tests of conidia of Sclerotinia after subjection to cold for varying periods of time.

DATE OF TEST	MEDIA	GERMINATION	NOTES
Nov. 4, 1912.....	Synthetic sugar broth	Nearly all germinated after 30 hours	No previous cold weather
Dec. 28, 1912....	Prune broth and prune agar slants	Germination of conidia as yet unaffected	Previous minimum −9°C.
Feb. 4, 1913.....	Synthetic broth and synthetic agar slants	Many conidia do not germinate even after 48 hours, but plenty of growth on both media	Previous minimum −21°C. but much fairly warm weather
March 21, 1913..	Synthetic broth	Good germination, but much fewer than on previous trials. Do not germinate as rapidly	Mild weather on the whole but one period with a minimum of −24°C.
April 17, 1913....	Synthetic broth	Many conidia will not germinate and others are slow in starting, but results are about as in previous test	Mild weather since the last test

and by April 25 were open enough to inoculate. Inoculations were made with a sterile needle both from the exposed pure cultures and mummied plums. The twigs were placed in water and a bellglass lined with moist filter paper was placed over the dish containing the twigs. Control buds were exposed to the same conditions. Infection was secured in six days on the plum and in four days on the cherry. The control buds kept healthy for nine days and then began to wither but without infection.

During the winter of 1913–1914, the material on these trees was so very scarce, owing probably to the very dry summer of 1913, that it was felt to be necessary to make inoculations on a few ripening plums. The inoculation was made from the pure cultures made the preceding year. Some of them were very successful and it was these artificially infected plums, enclosed in muslin sacks, that furnished the material for the second year's observations. The record for the observations made during this time is shown in table 2.

The last two tests made show that, while the extreme cold has had its effect in killing a large percentage of the spores, there were still an abun-

TABLE 2

Germination tests of conidia of Sclerotinia after subjection to cold for varying periods of time

DATE COLLECTED	MEDIUM USED	GERMINATION	NOTES
Dec. 18, 1913....	Tap water	Abundant growth in 24 hours. Practically all the conidia germinated	Previous minimum −12°C.
Jan. 1, 1914.....	Synthetic sugar broth	Same as above	Previous minimum −30°C.
Jan. 30, 1914.....	Synthetic sugar broth	Good germination but not as many show vitality as in previous test	Previous minimum −32°C.
Feb. 11, 1914....	Tap water	Only fair germination. Many conidia plasmolyzed	No lower temperature and warmer weather has prevailed
Mar. 21, 1914....	Synthetic broth	Scanty germination. Only a few conidia vigorous, others plasmolyzed	Long period of cold weather in February
April 17, 1914....	Tap water	Same as previous	Weather much warmer

dance of spores viable and apparently capable of producing infection. Unfortunately none of these conidia were used for purposes of infection of young flowers as had been done in the previous year, but there can be no doubt that it would have occurred as the germ tubes were long and apparently vigorous even in the germination in the tap-water.

The observations made during these two winters seem to warrant the following conclusions: (1) The Vermont brown-rot fungus conidia are resistant to a minimum temperature of at least −32°C. (2) Alternate freezing and thawing of the conidia tend to lessen their vitality but not entirely to destroy it. (3) Winter storms remove only a portion of the conidia from exposed mummied fruits.

In view of Ewert's work, the writer feels confident that our common native brown-rot fungus is *S. cinerea*. This belief is further strengthened by the measurements of the conidia obtained in this vicinity.

Measurements of conidia. Hundreds of conidia were measured in the attempt to get a representative average of the size of those derived from various sources. The measurements are given in micro-millimeters in table 3.

These conidia measurements are somewhat larger than those obtained either by Matheny or Conel, but do not approximate those given for *S. fructigena*. The measurements obtained for conidia from naturally infected plums agree exactly with those obtained by Reade (10) for the conidia of *S. fructigena*. The name in this case means nothing, however, as Reade found only one species present; and, as the name *S. fructigena* had the prior usage, he assumed it to be this form. Matheny found that the conidia obtained from mummied fruit from different parts of the country exhibit some variations in size. The larger size of the conidia obtained locally may have been such a sectional variation. In any case, there is not sufficient difference in size to justify the classification of our local fungus as anything other than *S. cinerea*.

TABLE 3

Average measurements of conidia of Sclerotinia

SOURCE OF CONIDIA	MINIMUM SIZE	MAXIMUM SIZE	AVERAGE SIZE
	μ	μ	μ
Plums	14.3 x 9	18 x 14.3	17 x 11
Synthetic agar	12.8 x 9	18 x 10.7	14.3 x 10
Prune agar	14.3 x 10.7	30.4 x 21.4	19.6 x 14
Plums, artificially inoculated	10.8 x 9	23.4 x 14.4	16.2 x 10.9

Color of conidial tufts. Ewert considers the yellow conidial tufts of *S. fructigena* and the gray ones of *S. cinerea* as one of the easily recognizable points of difference. The writer never has seen tufts of any color other than gray, either on diseased fruit or on pure cultures grown in the laboratory. Apples inoculated from pure cultures of the brown-rot fungus showed this color of the conidial tufts. In the inoculation tests made on buds and flowers, the fructifications were always ashy. The color of the tufts, therefore, would indicate further that our species is *S. cinerea*.

Disjunctors. Woronin (3) in his thorough investigations of these two species of Sclerotinia mentions the presence of disjunctors between the conidia of *S. fructigena* as a possible means of identification. No disjunctors were found on any of the local conidia examined. The conidia are fastened together in chains by their outer covering and separate by a tearing apart of this tissue. Woronin mentions this tearing apart of the connective tissue as a characteristic of *S. cinerea*.

Measurements of asci and ascospores. The peziza cups are rarely found in Vermont, only one lot ever having been seen here to the knowledge of the writer. A careful search during the past two years at the season when

they might have been expected, failed to reveal any, although mummied plums were observed in great abundance under the trees. The measurements made were taken from material obtained in the spring of 1909 at Madison, Wisconsin.

The ascospores were blunt at the ends as is characteristic for *S. cinerea*. The author's measurements are as follows: Average size of asci (120 measured) 150.4 by 8.8μ; average size of ascospores (180 measured) 10.1 by 7.1μ. These sizes agree with those obtained by Aderhold for the European form of *S. fructigena* but are larger than those he obtained for his *S. cinerea*. They also agree favorably with the measurements of Reade and Matheny (table 4) who worked on material found in this country. Just why the measurements do not agree more closely with those for *S. cinerea* is not certain; but all results show a wide variation in this one species.

TABLE 4

Measurements of asci and ascospores of Sclerotinia

AUTHOR	S. FRUCTIGENA		S. CINEREA	
	Asci	Ascospore	Asci	Ascospore
Aderhold	120–180 x 9–12	11–12.5 x 5.6–6.8	89.3–107.6 x 5.9–6.8	6.2–9.3 x 3.1–4.6
Reade	125–215 x 7–10	10–15 x 5–8		
Matheny	135–173 x 6.8–10.8 mostly 151 x 9.4	9.3–14.2 x 5–7.4 mostly 11.8 x 6.3		

CONCLUSIONS

Two general facts may be derived from the data presented above and their comparison with the results secured by European and other American investigators:

1. The common form of brown rot of stone fruits, as found in Vermont is due to the fungus known in Europe as *S. cinerea*. This is conclusively proved not only by the measurements of the conidia, the absence of disjunctors, the gray color of the conidial tufts, but more especially by the persistence of the vitality of the conidia through the winter.

2. The conidia, both those already present as well as those produced from the dormant mycelium in mummied plums, present a danger of early spring infections that has not been generally recognized. The spores from the apothecia are probably abundant in certain seasons, but in others they appear to be entirely absent and the conidia and dormant mycelium

serve to carry the brown-rot fungus over the winter. However, the fungus lives over the winter either in the form of conidia or of dormant mycelium which will yield conidial tufts during the first warm moist weather.

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NEW OR NOTEWORTHY FACTS CONCERNING APPLE RUST

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The apple rust fungus, *G. Juniperi-virginianae*, has been the subject of considerable study during the past few years. The writers have given much time and attention to investigations concerning its life history, and the control of the disease it causes. Some of the more important facts brought out in the work will be briefly mentioned.

There has been some difference of opinion as to how long a period of moisture was required to induce germination of teliospores. Good germination has been secured repeatedly after moistening a gall for from one to two hours, and abundant sporidial discharge has occurred within less than three hours after first applying water to a gall. Moreover, records of observations show that one such sporidial discharge, under normal field conditions, took place in from six to eight hours after rain first began to fall.

Forcible ejection of the sporidia has been observed and there is some evidence that an outer membrane or wall is ruptured at the base of the sporidium previous to the final act of discharge. Very few sporidia are discharged below a temperature of 50°F., even when the sori have been moistened for one to two hours in water at about 70°F.

Earlier field records showed a pronounced drop in humidity every time sporidia were discharged, but in 1915 there was a decrease in humidity of only 3 per cent. Laboratory experiments are being conducted to determine whether the sporida may be discharged in an absolutely saturated atmosphere.

On some occasions when there was an abundant sporidial discharge and the conditions as to moisture and temperature were favorable, it has been found that no infection took place even in nearby orchards. The failure of sporidia to produce infection in such cases was evidently due to insufficient air current. It would therefore seem that a wind of fairly high velocity would be required to disperse the sporidia in order to have a severe and widespread infection.

Contrary to this conception the infection which took place on May 12, 1915, was the most widespread yet observed by the writers, although the wind velocity was only one to two miles per hour. The temperature and humidity were remarkably constant during that infection period.

There was also considerable fog, a factor not previously considered, and this may have had an important part in distributing the sporidia over such a wide area.

Evidence has been secured showing that severe apple rust infections cause premature loss of foliage, decreased size of fruit, and very appreciable diminution in vigor of tree. It has also been found that the number of rust spots per leaf and the relative location of such infected leaves have a very definite relation to the number of leaves which fall during any certain period.

The destruction of cedar trees, *Juniperus virginiana*, for a radius of one-half mile around orchards has frequently been recommended as a means of control, but during the past season this disease was very destructive in orchards which had no cedars within one-half to three-fourths mile of them. The number and location of cedars would have important bearing on this point, but the writers do not believe that anything less than a mile radius should be considered, if good results are to be secured. The actual cost of cutting out red cedars as they occur in the eastern part of West Virginia does not appear to be very great. Figures for an area of over 1,100 acres showed an average cost of about forty-eight cents per acre.

Considerable attention is being devoted to a careful study of meteorological conditions as related to the different phases of apple rust infection. This is a many sided problem, but it is believed that a series of records extending over a period of several years will yield valuable results.

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THE CONTROL OF EXPERIMENTAL CONDITIONS IN PHYTOPATHOLOGICAL RESEARCH

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Few pathologists fail to recognize the desirability of controlling the conditions under which their experiments are conducted. Many have endeavored to control them in part, with varying degrees of success. There exists, however, as it seems to the writer, a fundamental necessity for improvement in this regard which is not fully realized. The realization of this necessity is doubtless largely contingent upon the recognition of the feasibility of accomplishing a real control of experimental conditions in botanical research. Nevertheless a consideration of the fundamental facts upon which the need of such control is based should assist materially in this realization which seems so much to be desired.

PRINCIPLES

Among the more highly developed organisms in which man is sufficiently interested to have made a study of their pathology the physical conditions of environment exercise a much more direct and therefore more immediately important influence on the plant forms than on those of the animal kingdom. The normal, warm-blooded animal has a constant temperature determined by the very nature of its existence, while its food supply is variable and must be sought by various adaptations to the nature of the supply. With its motility, an animal, or more specifically man, is thus so constituted that the physical conditions of environment affect him only indirectly. Given a food supply, his physical condition is largely determined from within.

With autotrophic plants it is evidently quite otherwise. Their photosynthetic elaboration of a food supply, not their temperature or other physical condition, is the distinctively fundamental fact of their existence. Given a suitable physical environment, the plant is able through this inherent anabolic process to supply its own nutrition from the inorganic materials of soil and air. The metabolism of the plant is thus directly dependent upon external, physical conditions. As compared with that of an animal, therefore, the response of a plant to changes of this character is more immediate and more profound.

While it seems scarcely necessary to recall these fundamental distinc-

tions to anyone engaged in biological research, they are thus briefly summarized in order to point out the influence which they have had on the development of pathological science. This is in part at once evident. The science of medicine, even to the etymology of its name which it has outgrown, has developed about a system of therapeutics or curative measures, and these have been and still are in practice largely a matter of influencing conditions through the alimentary system: in simpler language, a matter of dosage or of diet. In phytopathology, on the other hand, therapeutics of any sort are of comparatively little avail.

The fact, however, that prophylactic measures and the general technique of research have been so highly developed in the study of animal pathology has led to a general acceptance of medical methods as a guide in the development of the newer field of phytopathology. There is much to be gained thereby, for certain basic principles, particularly in matters of sanitation and antisepsis, must be recognized as common to both. But it would seem necessary in connection with the recent rapid development of phytopathology to point out the dangers of drawing too close an analogy between the two. May we not otherwise fall heir to methods which really take no cognizance of things which are fundamental in the existence of a plant?

The cardinal requirements for the determination of pathogenicity, as propounded by Koch with reference to the study of bacterial diseases, have only too recently been given prominence among workers with plants. In dealing with facultative saprophytes and parasites these rules of proof are manifestly a desideratum; yet where the parasitism is obligate they are at least of obscure application and in those cases in which the parasite itself is much more evident than any lesions or other signs of disease (e.g., rusts and smuts) they would even seem immaterial. Where parasites are not concerned they are, of course, essentially irrelevant.

The determination of pathogenicity by Koch's rules, however, *may* be of little significance even where lesions are produced. That a plant or portion of it should wilt or assume some abnormal coloration in the presence of some cryptogamic invader is of little significance unless the other conditions be stated; and if these be not normal to the host then a true pathogenicity, or at least its true nature, has not been determined. The test loses significance to the extent that conditions have varied from the normal. The fact that this is peculiarly true in phytopathology on account of the more direct and fundamental dependence of the plant upon physical conditions, as pointed out above, seems to have been largely overlooked in the adoption of medical methods of investigation in which dietary and other considerations have necessarily somewhat obscured the matter of physical environment. Important though the latter may

be to the animal, the essential point is that it is more immediately important to the plant and more fundamentally so.

But what of the cases of obligate parasites and of diseases of non-parasitic origin? Here are some of the most pressing and most difficult of our problems; difficult because in basing our technique on Koch's rules we are able only to collect negative evidence as to the pathogenicity of the more or less numerous saprophytic organisms present; or in endeavoring to study the physiological relations involved we are confused by the continual entrance of extraneous organisms.

If a sound technique is to be developed for this class of investigations we must again revert to a fundamental difference between plants and animals. It must be recalled that the infectious diseases of the latter are largely transmitted by infected food and by contact, while with the diseases of plants other agencies or carriers must usually enter into the cycle. The soil, and particularly the atmosphere,[1] are the foremost of these and for this reason the isolation of plants from any given infection is much more uncertain in the open field than is ordinarily the case with animals.

Our attempts to depend entirely upon medical standards of quarantine or isolation in investigations of pathogenic conditions have here led us into numerous difficulties. Many observers, by creating or observing variations in the environment of plants, as for instance in the use of fertilizers or of irrigation, have shown that certain conditions bring on abnormalities of a definite sort in the crop plant. They have then concluded that these conditions were the primary cause of the disturbance, forgetting that were the disease etiologically parasitic, the physiological phenomena in both the pathogene and the host, and in either case the reaction between the two, unquestionably would be influenced by the change in environmental conditions. As R. E. Smith[2] has recently pointed out, it is safer, with our present technique, to admit that a disease is etiologically unknown than to pronounce it a physiological[3] disease.

In brief, just as on the one hand a lack of control of physical conditions may lead to doubt as to the extent of the pathogenicity of an organism, so on the other hand the possible presence of an organism of any sort casts serious doubt on conclusions that a given disease is primarily due

[1] According to Chapin (Chapin, Charles. The Sources and Modes of Infection. p. 313–314. New York, 1910.) the evidence of pathogenic infection of man through the atmosphere is practically negligible.

[2] Smith, Ralph E. The investigation of "physiological" plant diseases. Phytopath. **5**: 83–93. 1915.

[3] Melchers (Melchers, L. E. The grouping and terminology of plant diseases. Phytopath. **5**: 297–302. 1915.) has recently contended, and rightfully it would seem, that "physiological" is not a distinctive term to apply to any class of plant diseases.

to a physiological disturbance. It is thus of utmost importance to determine all the conditions of the plant's environment during an experiment.

PRESENT PRACTICE

In dealing with plants in the field these principles are at present applied in measuring physical conditions by the use of recording instruments. These are commonly in use by physiologists and ecologists. While the physiologist not infrequently neglects pathological factors and obtains fairly accurate approximations only by averaging large numbers, this does not justify the pathologist in neglecting the consideration of physical conditions. Indeed, he has double reason for considering them for he has to deal at once not alone with the physiology of a green plant, but also with that of the parasite. The physical conditions at the time of planting and during early development of cereals affected by smut, for instance, have an important bearing on the severity of the attack. Yet we have too little complete and accurate information in the matter and this can not be said to be an exceptional case. Data of this character should be sought by a study of field conditions.

In the field we are handicapped, however, by a serious difficulty, namely, the impossibility, in many cases, of controlling or measuring the biotic factors in the natural habitat. It is, in short, often impossible to run control or check plants in the field on account of the omnipresence of some parasite. We might cite, for instance, the cases of corn smut and the rusts of small grains. It sounds strange to have to confess that for this reason we have no definite criteria by which to estimate the effect of stem rust on the wheat plant. Indeed, American pathologists have been criticized by European reviewers for the statement that the reduction of the wheat crop in 1904 represented *in toto* a loss due to rust.[4] Field experiments and observations can never definitely answer such criticism.

A distinct case, however, presents itself in the greenhouse. Here the conditions are artificial, and unless carefully controlled are normal to comparatively few of our economic plants. Yet the control of physical conditions alone, which might be obtained in the greenhouse, is of superlative value to the experimenter.

The control of the atmosphere in the greenhouse laboratory assumes an added importance, however, if conditions which are sterile, or at least free from pathogenic organisms, could be obtained. Pure or at least known cultures have long been recognized as essential to a careful study of organisms in test tubes, yet the student of green plants seldom attempts

[4] Riehm, E. Getreidekrankheiten und Getreideschädlinge. Centbl. Bakt. [usw.] II, **34**: 452. 1912.

a culture of known composition or even a culture which he *knows* to be free from pathogenic organisms. The greenhouse is no more free from contamination than is the vicinity in which it is located—in many cases even less so. In flasks and similar apparatus[5] the experimental isolation of green plants has been attempted on a small scale, but the serious limitations of such methods need not be enlarged upon. If sterility of environment is indeed obtained, the other conditions become so distinctly abnormal that most plants do not long survive the seedling stage. Many physiologists have excused the dearth of studies under conditions of pure culture by the fact that sterility of environment is not normal to green plants. While it may be wondered why it is assumed to be any more normal to other organisms, the pathologist, at least, can not seek refuge in this generalization, for his is the task of analyzing conditions which are *not* normal.

IMPROVEMENTS

Field conditions do not appear to offer great opportunity for radical improvement in available technique. In the greenhouse, however, the zoologists and entomologists are setting an example to which attention should be directed. Having come to at least a partial realization of the needs of experimental work connected with the growth of plants, they have spent and are spending liberally in efforts to control the physical conditions of their experiments. That their efforts, along with those of many botanical workers, seem in many cases to have been of little avail, may be attributed to the fact that their instrumentation has been largely of their own devising and has lacked the efficiency of construction which only a trained and experienced engineer could give it.

At the Kansas State Agricultural College, however, these attempts were abandoned recently in favor of a carefully developed system which has been installed under the supervision of the Division of Engineering by the Departments of Zoology and Entomology. Many such systems[6] have been designed in recent years for conditioning the air in a great variety

[5] These methods are summarized by Viktor Grafe in his Ernährungsphysiologisches Praktikum der höheren Pflanzen, p. 313–325, fig. 84–91. Berlin, 1914.

[6] For details of the principles of physics and engineering involved see:

Carrier, Willis H. Rational psychrometric formulae, their relation to the problems of meteorology and of air conditioning. Jour. Amer. Soc. Mech. Engin. **33:** 1309–1350, 14 fig. 1911.

Carrier, Willis H., and Busey, Frank L. Air-conditioning apparatus, principles governing its application and operation. Jour. Amer. Soc. Mech. Engin. **33:** 1611–1688, 43 fig. 1911.

Lyle, J. I. Atmospheric dehumidifying. Trans. Amer. Soc. Refrig. Engin. **8** (1912): 127–154, 16 fig. 1913.

of structures and they are now in operation in various industries such as silk mills, pottery works, lithographing establishments, and so forth, not to mention the ventilation of public buildings. Forced ventilation with washed air is the main advantage which these systems offer.

The greenhouse chamber installed at Manhattan, Kansas, has been in operation for a year, and has been described by Dean and Nabours.[7] A glance at the charts of temperature and humidity given in connection with this description will convince even the most skeptical that, within limits, the control of physical conditions in a greenhouse can be accomplished. The writer has seen the apparatus in operation and has been assured by those who have operated it that with proper attention it is capable of producing such results consistently.

Successful control should reasonably be expected to follow the careful application of correct principles. A forced change of air every minute (more or less according to the needs of the case in hand) necessarily provides a more adequate and responsive means of control than obtains in the commercial type of greenhouse. When the entering air is properly conditioned, the control approaches perfection. This, in principle, is most satisfactorily accomplished by thermostatic control of the temperature of the water spray through which the air passes (thus determining the dew point) and subsequent re-heating, also under thermostatic control, to a given point of saturation deficiency. Some manufacturers guarantee to furnish apparatus which will control a given set of atmospheric conditions within a range of 2°F. and 2 per cent relative humidity.

In the control of physical conditions, then, the only difficulty offered, aside from the control of light, is that of stating the conditions to be met in a greenhouse. In order to furnish specifications as to the capacity of the machinery to be installed we have to know (1) the minimum dew point required; (2) the maximum number of thermal units to be absorbed in a given time, which includes the refrigeration required to absorb the water transpired by the plants; (3) the maximum number of thermal units to be supplied in a given time. These data are dependent chiefly upon the experimental conditions of temperature and humidity which it is proposed to maintain as related to the climatic conditions under which it is proposed to operate the laboratory. Within reasonable limits of control the solution of such problems as arise is purely a matter of the capacity of the machinery to be provided and thus, of expense.

[7] Dean, George A., and Nabours, R. K. A new air-conditioning apparatus. Jour. Econ. Ent. **8**: 107–111. 1915. The writer took up the question of similar equipment with the company which installed the Kansas plant, in the fall of 1912. He wishes to disclaim credit, however, for being the Mr. A. A. Potter to whom acknowledgments are made in this article.

Light conditions, however, since artificial light is of little or no avail for the photosynthetic activities of the plant, are the most difficult to control. For this reason, and also because humidity would be more easily controlled in a dry climate especially during warm weather (thus saving expensive refrigeration), the most suitable location for such a greenhouse laboratory would appear to be in a climate of little rainfall. In such a location maximum light conditions would be available most of the time and their reduction to any desired degree of intensity would be a comparatively simple matter.

But the control of physical conditions is not alone of importance. If sterility can be maintained the installation of an air-washer would be justified even if temperature and humidity were controlled no better than is now done. The incorporation of air-washers in ventilation systems, however, appears never to have been attempted as yet with this object in view. Specific data on which to base a prognosis of success in this direction are therefore largely lacking. Claims are made by some manufacturers that "absolutely clean air" is delivered by their washers. However, in recent tests of five washers in public buildings in Boston, Whipple and Whipple[8] have found that only about two-thirds of the suspended particles in the air were removed. In a recent letter to the writer,[9] the junior author, Prof. Melville C. Whipple of Harvard, gives it as his opinion that "these installations could be made to operate more efficiently if they were used for experimental work." He notes also that sterility is more easily obtained than absolute purity, i.e., freedom from all dust. It would seem that modifications of the present types of air-washers, designed to obtain the sterility of the air (possibly by the simple addition of active germicides to the water) could attain this end beyond a reasonable doubt.

That we should acquire at once, however, an apparatus precisely fitted to the needs of every problem presented is scarcely to be expected. Experimental apparatus must often be modified to fulfill the needs of the case in hand, as every research worker well knows; but that machinery has already been devised which in principle does answer the needs of the day in phytopathological research can no longer be doubted.

The expense involved is considerable; this can not be gainsaid. The Kansas installation, complete, has cost perhaps $2,000 and its operation requires $2\frac{1}{2}$ H.P. and enough oil, labor, repairs and other expenses to make up a daily operating cost of fully $3.[10] But even presuming that this first,

[8] Whipple, George C., and Whipple, Melville C. Air washing as a means of obtaining clean air in buildings. Heat. and Vent. Mag. **10,** no. 9: 13–19. 1913.

[9] Letter of November 19, 1915.

[10] Exclusive of power and heat the costs are about $1.00 per day. The writer is indebted to Dr. Nabours for the figures given.

small, experimental installation could not be improved upon as to costs, the matter of expense does not appear to be of material significance as compared with the ends to be gained.

For the control of physical conditions, the pathologist needs such a greenhouse equipment twice where the physiologist needs it but once; but even more does he need it for the conducting of pure culture experiments on the host. Can one call to mind such controversies as those on carnation spot, mosaic disease, crown gall, citrus canker, or the mycoplasm theory of Eriksson with his apparatus[11] for attempting the solution of the problems involved (and they are problems still much in dispute), without wondering what might not have been saved, or may not still be saved by a realization of the inadequacies of the technique employed in attacking these problems? Methods are needed by which Koch's rules may be applied with more facility and greater accuracy to those problems involving pathogenes of a more or less saprophytic character; but more especially must these methods also open up the way to a solution of the much more difficult problems of obligate parasites and non-parasitic diseases. In developing this technique we must recognize more fully that what Vice-President Zeleny has said in his recent address before the Section of Physics of the American Association for the Advancement of Science, namely that real progress in science is dependent upon the development of instruments, is as true in the field of botanical research as in any other line of investigation.

OFFICE OF CEREAL INVESTIGATIONS
BUREAU OF PLANT INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE

[11] Eriksson, Jakob. Sur l'origine et la propagation de la rouille des céréales par la semence. B.-Essais de cultures isolées. Ann. Sci. Nat. Bot. VIII, **15**: 1–50, pl. 1–2. 1902.

PHYTOPATHOLOGICAL NOTES

The Phytophthora rot of apples. About the first of July, 1915, the senior author observed a peculiar brown rot lesion on several half-grown Oldenburg apples in his garden. The affected fruits were on the lower branches near the ground. Diseased fruits were found from time to time on the tree until the fruit began to ripen. The lesions resembled very much those produced by *Bacillus amylovorus*. No insect punctures were evident through which a pathogene might have been introduced. When placed in a moist chamber, the entire fruits became involved within two days. Isolations gave pure cultures of a Phytophthora which promptly produced conidia on potato agar. Cultures of the fungus were sent to the junior author who made careful comparison, on various media, with other Phytophthoras which he had growing. It is evident that the fungus is *P. cactorum* (Lib. et Cohn) Schroet.

Two series of inoculations of eight to ten apples each with the mycelium from pure cultures into healthy Oldenburg apples on the trees gave typical infections in every case. The junior author made similar inoculations from pure cultures of the organism into Rhode Island Greening apples at Presque Isle, Maine, and obtained like results.

Osterwalder[1] reports a rot of apples and pears which he found prevalent during early July of rainy seasons in Switzerland and which he attributes to *P. omnivora* de Bary (= *P. cactorum*). He found both conidia and oospores of the pathogene on rotted fruit on the ground. He also observed infected apples on low-hanging branches. He later reported this pathogene attacking nursery apple "buds"[2] during the first season of growth, girdling them. Bubák[3] records an outbreak of this disease in Bohemia on pears in 1910.

During October and November, this same pathogene was again twice isolated from apples purchased in the Ithaca market, once from a Tompkins King and on another occasion from Twenty Ounce. These isolations were made by Mr. Fernow, a student working on apple fruit rots, under the direction of Professor Hesler.

The writers have made no extensive study of the disease and report it only because this appears to be the first recorded appearance of the

[1] Centrlb. Bakt. 2: **15**: 435–440. 1905.
[2] Landw. Jahrb. d. Schweiz **26**: 319. 1912.
[3] Zeitschr. Pflanzenkr. **20**: 257–261. 1910.

pathogene on orchard fruits in this country. While Osterwalder regards it as destructive in wet seasons in certain varieties of apples and pears, the disease, as we have observed it, seems to promise little of danger to the fruit industry in this country.

H. H. WHETZEL
J. ROSENBAUM

Violet root rot of alfalfa in Virginia. In a survey of diseases of alfalfa in Virginia during the season of 1915, the presence of the violet root rot fungus, *Rhizoctonia crocorum* (Pers.) D.C. (*R. medicaginis* D.C., *R. violacea* Tul.), is noteworthy. It was found in a single field at Daleville, Botetourt County. A previous record of this disease from the same field, on material sent to them in 1914, was made by Reed and Crabill.[1] The fungus appears to be confined to the single field in this locality at present and is not known to be in any other locality in Virginia. This field is about eight acres in size and the alfalfa of five years' standing. The death of tops due to the fungus was first observed by the owner in 1914 and was said to be noticeable only on the last cutting, late in October, in both 1914 and 1915. An examination of the field showed the presence of the fungus, chiefly in the lower portions, marked by bare areas roughly circular in outline and six feet or less in diameter. Roots of dead and dying plants within these areas presented the typical appearance of the Rhizoctonia attack; the complete envelopment of the roots in a mat of violet-colored mycelium with numerous small "infection cushions" and hyphal strands, and the slipping of the bark from the root in pulling. The determination of the fungus as *R. crocorum* has been verified by Dr. B. M. Duggar and Dr. G. L. Peltier.

This record materially extends the known distribution of *Rhizoctonia crocorum* in the United States, being the first from the Atlantic States, so far as I am aware. Duggar[2] records reports of this fungus on alfalfa from Nebraska and Kansas and on potato from Oregon. The appearance of the fungus in isolated sections is suggestive of a more general distribution and of its probable introduction with imported seed.

F. D. FROMME

[1] Reed, H. S., and Crabill, C. H. Notes on plant diseases in Virginia observed in 1913 and 1914. Virginia Agr. Exp. Sta. Tech. Bul. 2: 37. 1915. Published also in Virginia Agr. Exp. Sta. Ann. Rept. 1913–14: 37. 1915.

[2] Duggar, B. M. Rhizoctonia crocorum (Pers.) D. C. and R. solani Kühn (Corticium vagum B. & C.) with notes on other species. Ann. Mo. Bot. Gard. **2**: 403–458. 1915.

Note on the white spot of alfalfa. Stewart, French, and Wilson[1] have described a white spot disease of alfalfa leaves. A similar trouble has been observed in Virginia for a number of seasons. Although the losses from it are not serious, farmers frequently inquire about it.

The disease may be described as rectangular, whitish-translucent spots on the leaves, chiefly on the distal portions. The spots are thin and the cells of the affected area are flaccid. The epidermis of both the upper and lower surfaces is unruptured. Affected plants are usually unthrifty

FIG. 1. A typical case of white spot. Almost every leaf on the affected plant is spotted while the surrounding plants are entirely healthy.

and make a poor growth. It is probable that most of them soon die. This disease has been observed only prior to the first cutting.

Microscopic examination of whole spots and of razor sections of fresh material has revealed no parasite. Stained sections of imbedded material likewise give no clew to the cause of white spot. Thrust and dilution cultures on starch, protein, and sugar media have indicated an absence of parasitic fungi.

[1] Stewart, F. C., French, G. T., and Wilson, J. K. Alfalfa troubles in New York. New York State Agr. Exp. Sta. Bul. 305. 1908.

Affected plants show the spot on nearly every leaf, while adjacent plants are entirely free from the disease (fig. 1). This observation led to an examination of the root systems. The root below the crown was always found normal except for superficial injuries which were caused by chewing insects and which were common on all plants in the vicinity.

The upper surface of the crown, however, was always found in a state of decay. Sometimes this decay extended a short distance down into the pith of the taproot and up into the pith of the stems (fig. 2). The pith had turned brown and the cells separated very easily. From this tissue,

FIG. 2. The crown of the alfalfa plant shown in figure 1.

Fusarium sp. and *Acrostalagmus* sp. were isolated by thrust cultures[2] on starch agar.

The fact that the crowns of plants showing white spot were always injured, while those of unaffected plants were not, pointed to the conclusion that the crown injury was directly responsible for the spots. Why this should be true lacks explanation but it is evident that the transpiration stream is interfered with.

Some healthy alfalfa plants were wounded by cutting away a portion of the tissue of the crown from above. On all of these plants typical white spots developed on the younger leaves in twelve days.

[2] Made by thrusting small pieces of tissue into solidified agar in petri dishes.

The fact that white spot appears only in early spring indicates that the injury which produces the disease occurs in late fall or winter and that after a period of feeble growth in spring the plant either recovers by repairing the injury or dies outright. C. H. CRABILL

Horse-chestnut anthracnose. During the season of 1914 the petioles and the midribs and veins of the leaflets of *Aesculus hippocastanum* Linn., in Washington, D. C., were commonly affected with anthracnose. A species of Colletotrichum was found fruiting abundantly on the lesions. The spores measured 4 to 4.9 by 14 to 21μ; on specimens taken in autumn the spines were very conspicuous, dark, several septate, 7 to 9 by 93 to 140μ. At first peripheral tissues only were affected. The fungus often produced acervuli on the lesions before conduction was cut off. In most cases the fungus ultimately penetrated to a sufficient depth to cause the killing of all tissues beyond the point attacked. Infection of the petiole at the point of juncture with the leaflets frequently occurred. Simultaneous wilting and drooping of all the leaflets, or of two or three of them, as a result of such petiole infection, was a rather common phenomenon. Lesions on the leaf blades were very closely limited to the veins, distinguishing the trouble from the leaf blotch and from non-parasitic leaf injury found on the same trees.

Living leaves of *Aesculus hippocastanum* with the typical petiole anthracnose were received from New Rochelle, New York. One of these lesions contained the fruits of an ascomycete, paraphysate, with 8-spored asci. The ascospores were oblong-ellipsoid, 1 to 2-seriate, 4.7 to 6.1 by 14 to 16μ. There is reason to suspect that both the ascomycete and the Colletotrichum found are identical, and should be referred to *Glomerella cingulata.* ROY G. PIERCE
CARL HARTLEY

Personals. Mr. C. H. Crabill, formerly assistant plant pathologist of the Virginia Agricultural Experiment Station, resigned this position on September 15 to engage in farming. His present address is Cliffside Farms, Ethelfelts, Virginia.

Dr. F. M. Rolfs, formerly associate botanist and plant pathologist of the South Carolina Experiment Station, has accepted the position of horticulturist of the Oklahoma Agricultural College and Experiment Station, effective January 1. He is succeeded by Mr. Roy C. Faulwetter, formerly assistant in Botany at Columbia University.

Mr. J. G. Grossenbacher, pathologist in charge of citrus disease investi-

gations, Office of Fruit Disease Investigations, Bureau of Plant Industry, has resigned this position and has been succeeded by Prof. H. R. Fulton, formerly plant pathologist of the North Carolina Experiment Station. The latter vacancy has been filled by the appointment of Dr. F. A. Wolf, who previously held a similar position at the Alabama Experiment Station.

ABSTRACTS OF PAPERS PRESENTED AT THE SEVENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, COLUMBUS, OHIO, DECEMBER 28–31, 1915.

Pathological quarantines in 1915. R. KENT BEATTIE

Under the authority of the Plant Quarantine Act of August 20, 1912, the Secretary of Agriculture has established foreign quarantines aimed at injurious plant diseases which in their present status exclude from the United States:

(1) All five-needle pines from Europe and Asia (because of the white pine blister rust); (2) potatoes from Newfoundland, St. Pierre, Miquelon, Great Britain, Germany, and Austro-Hungary (because of the potato wart) which quarantine is extended (because of the powdery scab) to include also Canada and all of continental Europe except Denmark and most of the Netherlands; (3) sugar cane from all countries (because of several serious diseases); (4) Citrus from all foreign countries (because of Citrus canker and other serious diseases); (5) corn from Java and India (because of *Sclerospora maydis*).

In addition to the above, Foreign Quarantines, established primarily to exclude certain insects, assist in guarding against the entrance of foreign plant diseases. Such quarantines exclude:

(1) Seven different kinds of fruit from Mexico; (2) cotton seed and hulls from all foreign countries (except Lower California); (3) avocado seed from Mexico and Central America; (4) two- and three-needle pines from Europe.

Domestic quarantines almost prevent the movement of cotton seed, hulls, and lint and of thirty-five different kinds of fruit from Hawaii to the mainland.

The potato powdery scab quarantine. R. KENT BEATTIE

The principal Domestic Quarantine aimed at the restriction of a plant disease which has been established under the Plant Quarantine Act is that regulating the movement of potatoes from the regions in Maine and New York infected with powdery scab.

The quarantine was designed to restrict the movement of this apparently dangerous introduction from Europe till its seriousness under our conditions and its relation to American agriculture could be determined.

The disease was discovered in Maine in the 1913 crop, the movement of which was regulated by the Maine authorities. Federal quarantine became effective in Maine August 1, 1914 and in New York, November 16, 1914.

The entire crop of the infected area was inspected and 27,600 cars were permitted to enter interstate traffic. As many as 132 inspectors were at work at one time. Potatoes were shipped to thirty-four different states. Not over sixty bushels of these went to the northern tier of states west of New England.

A careful survey of the potato-growing states which used Maine seed showed that the disease had established itself in but one place, a slight infection in northeastern Florida. Experiments reported by the Bureau of Plant Industry confirmed the probability that this disease would not become serious outside of the northern colder regions.

A Federal survey located the disease at one point in Minnesota and the state authorities reported four other infections. Three infections were reported from Oregon and one from Washington State by the state authorities. Federal quarantine being thus unnecessary for the southern states and having no effect on the northern ones, the quarantine was removed on September 1, 1915.

The phytopathological inspection service of the United States Department of Agriculture. G. R. LYMAN

The work of the pathological inspectors of the Federal Horticultural Board under the Plant Quarantine Act of 1912 falls into two categories:

I. Inspection of nursery stock privately imported from abroad or moving into or out of the District of Columbia in ordinary interstate shipments. Only woody plants or their parts for propagation are subject to inspection.

II. Inspection of government importations. Here all plant material for propagation must be examined by pathological and entomological inspectors. This material is large in quantity, comes from every quarter of the globe and is unlimited in variety both as to host plants and as to fungous and insect pests found thereon. After examination this material may be (1) passed with or without preliminary treatment; (2) grown in close quarantine; or (3) destroyed. The specially constructed inspection house adjoining the quarantine greenhouse is equipped with every facility for examination and treatment of plants and may be disinfected at will. Precautions similar to those used in contagious wards of hospitals are employed in suspicious cases. After passing inspection most plants are propagated at Yarrow, Md., where they are examined and treated periodically and again minutely inspected before final distribution.

Some interesting finds in the phytopathological inspection service for 1915. G. R. LYMAN

The following finds are of sufficient general interest to merit mention.

Citrus canker was discovered on nineteen different lots of citrus bud wood from the Philippine Islands. Citrus canker was not known to occur in the Islands and this discovery led to an investigation which showed canker to be well established there. Wither tip was detected on twelve lots of citrus bud wood from the Philippines and also on one shipment each from Japan, Peru, Australia and the Fiji Islands.

Powdery scab was detected on fifteen lots of potatoes from three localities in Peru. The presence of this disease on native varieties of potatoes grown near the upper limits of potato culture on the eastern slope of the Andes where potatoes are never imported seems to show that the disease is indigenous there. Powdery scab was also found on potatoes from Ireland.

The detection of the "Dutch Bulb Disease" due to *Botrytis parasitica* on two shipments of tulip bulbs to the Department of Agriculture from the United States Bulb Garden at Bellingham, Washington, revealed the presence of this disease in that garden. The same disease was found on tulips from Ireland and on narcissus from Holland.

Observations on the occurrence of Puccinia glumarum in the United States. H. B. HUMPHREY AND A. G. JOHNSON

Puccinia glumarum Erik. and Henn. was observed in the United States for the first time by F. Kølpin Ravn of the Royal Agricultural College of Copenhagen while inspecting a wheat field near Casa Grande, Arizona, in May, 1915. This species of Puccinia was first recognized and described by Eriksson and Henning in 1890,

prior to which time it had been confused with *P. dispersa*, *P. graminis*, and *P. coronata*. Thus far, in the United States, it has been observed on *Triticum vulgare*, *T. compactum*, *T. durum*, *T. polonicum*, *T. spelta*, *Secale cereale*, *Hordeum vulgare*, *H. murinum*, *Elymus canadensis* and *Bromus marginatus*. Geographically it seems thus far to be confined in this country to the Pacific Coast and intermountain states. Nothing is known of the source of its introduction into the United States, nor as to the length of time it has existed in the western states. The symptoms manifested by plants attacked by *P. glumarum*, though somewhat variable, are in the main not unlike those shown by those infested with *P. triticina* or *P. graminis* in the uredo stage. In the former, however, the smaller and roundish, bright yellow uredo-sori occur in definite lines or series, while in *P. triticina and P. graminis* the sori appear with less definiteness of arrangement. Because of the characteristic type of lesion produced by *P. glumarum*, Parker has proposed the adoption of the name stripe rust in order the more clearly to define this species from *Puccinia triticina* with which it is often confused. The teleuto-sori develop in long black lines on the leaves, culms, and glumes of the host. Our observations record but three varieties of wheat in which glume infection produced either uredo- or teleutospores. The severest epidemic of this rust was observed on the U. S. Experiment Farm at Moro, Oregon, where grain is grown without irrigation and where the average annual rainfall is approximately 11 inches and the average annual evaporation is approximately 45 inches.

Certain varieties (Dale's Gloria and Early Baart) showed an estimated infection of 70 to 90 per cent. Yet it has been shown, contrary to results observed in Sweden and elsewhere in Europe, that the varieties grown at Moro showing severest infection gave the highest yields. Notes on varietal susceptibility were taken at Moro, Oregon, and Moscow, Idaho, the two points where the epidemics seemed most severe.

Preliminary notes on an heretofore unreported leaf disease of rice. G. H. GODFREY

Early in the fall of 1914, the writer observed in the rice-fields of Louisiana and Texas, in great abundance, a peculiar leaf-affection of rice plants. At a casual glance it resembled ordinary black rust of cereals, in fact, many of the growers spoke of it as rust. At that time, and since then at several different times, searches were made for pustules or other forms of fruiting bodies, and attempts were made to get the organism to produce spores, but thus far without result. Sections through the leaf showed a spot to be apparently a solid stromatic mass extending down into and replacing the host tissue. Attempts to culture the organism in agar plates and in sterile tubes containing moist cotton plugs resulted constantly in the development of numerous small black sclerotia-like bodies. They seem to develop directly upon mycelia growing out of the stromatic mass in the leaf. Preliminary inoculations with fresh cultures of these sclerotia-like bodies have produced definite lesions, the leaf becoming interlaced with strands of mycelium which have begun to mat together to form a definite stroma in the upper layers of the leaf. Artificial inoculations, however, have not yet produced the appearance of general infection which occurs on the leaf in nature. While the writer thinks it has been demonstrated that the organism he has obtained in culture is the causal organism, it still remains to identify that organism definitely, and to determine the conditions under which universal infection of the leaf takes place and the other usual details of pathological significance.

Further results in controlling certain barley diseases by seed treatments. A. G. JOHNSON

Using seed known to be infested with stripe disease (*Helminthosporium gramineum*), loose and covered smuts (*Ustilago nuda* and *U. hordei*), a series of seed treatments was run at Madison, Wisconsin, during the past season. These included copper sulphate (concentration and time of exposure were varied), copper sulphate and salt (concentration and time varied), bordeaux mixture (time varied), formaldehyde (strength of solution, time, and temperature varied), mercuric chloride (time and temperature varied), and three standard hot-water treatments. The series covered 57 plats, including 3 controls. Each plat consisted of six rod-rows.

Practically all of the treatments greatly reduced, and a number eliminated perfectly, the loose smut as well as the covered smut, while controls uniformly showed considerable infection from both. The stripe disease was reduced by a considerable number of the treatments, but was eliminated perfectly by only three as follows: (a) 40 per cent formaldehyde, 1 part to 240 parts water at 20°C., seed soaked 3 hours; (b) 40 per cent formaldehyde 1 part to 160 parts water at 10°C., seed soaked 2 hours; (c) 40 per cent formaldehyde 1 part to 160 parts water at 25°C., seed soaked 1 hour. In all three of these, germination was unimpaired and both smuts, as well as stripe disease, were eliminated perfectly. Controls averaged 11.7 per cent stripe disease, 1.1 per cent loose smut, and 1.8 per cent covered smut. Aside from formaldehyde, the copper sulphate and salt mixture gave best results, eliminating both smuts perfectly and leaving only two stripe disease plants in the entire plot.

A bacterial disease of barley. L. R. JONES, A. G. JOHNSON AND C. S. REDDY

The disease in question has been under observation during the past four seasons. It was first observed at Madison, Wisconsin, on two-rowed barley and later also on the square six-rowed varieties. The disease has also been noted on a wide range of barley varieties in the following states: Minnesota, North and South Dakota, Montana, Colorado, and Oregon.

The disease manifests itself chiefly on the leaves. As to form and size the lesions vary from irregular spots of various sizes to rather narrow stripes which may extend practically the entire length of the leaf. The lesions show a characteristic translucency, both when fresh and later when dried. They are at first water-soaked and later dry to a light brown color. A bacterial exudate is usually present on the lesions. Under humid conditions this may appear as numerous tiny droplets of cream-like color and consistency and is teeming with bacteria. With excessive moisture this may spread as a film over the surface. Under drying conditions this exudate quickly hardens into yellow granular beads or glistening scales easily detached and readily softened or dissolved again in water.

Isolation and inoculation work has shown the disease to be due to a single yellow organism. Numerous isolations have been made, characteristic lesions obtained, and the organism reisolated. The organism is short, rod-shaped, and actively motile with a single polar flagellum. Thus it is referable to Migula's genus Pseudomonas or Cohn's Bacterium as emended by Smith. The species is apparently undescribed. Work on the disease is being continued.

A bacterial disease of western wheat-grass. Occurrence of a new type of bacterial disease in America. P. J. O'GARA

An unusual type of bacterial disease has been found occurring on western wheatgrass, *Agropyron Smithii*. Rydb., in Utah Valley and Salt Lake Valley, Utah. Affected plants are usually somewhat dwarfed, but the most striking characteristic

of the disease is the presence of enormous masses of surface bacteria which produce a primuline yellow ooze or slime, forming layers between the stem and the upper sheath and between the glumes of the inflorescence. The floral organs are also extensively occupied by the organism. Knee-shaped bendings are often produced in the stem just above the upper node and these often protrude through the sheath. This usually occurs when the space between the upper internode and its surrounding sheath is entirely occupied by a deep layer of bacterial slime. The organism does not penetrate into the tissues until some time after it has covered the surface of the plant. It is then found in the sub-stomatic chambers and in the intercellular spaces. It has not been found occupying the cells.

The infected inflorescence rarely ever produces normal, germinable seeds. Thousands of infected spikelets have been examined and in no case have fertile seeds been found.

The organism has been studied in culture for several months and is found to be more or less closely related to *Aplanobacter Rathayi*, E. F. S., which causes a very similar disease of orchard grass, *Dactylis glomerata*, L. The organism, being nonmotile, belongs to the genus Aplanobacter. The writer proposes to describe the organism causing the bacterial disease of western wheat-grass as a new species of Aplanobacter.

Pathological morphology of wheat affected by stinking smut. MORTIER F. BARRUS

Published in full in this issue of Phytopathology.

Culture work on the heteroecious rusts of Colorado. ELLSWORTH BETHEL

Results are recorded from field and garden cultures of a number of heteroecious rusts. The work has extended over a period of five years, during which it was usually possible to duplicate the trials more than once in a season and to repeat them from year to year. The final conclusions are based upon the uniform success obtained by these repetitions. Extended and persistent observations in the field, pursued for a long period of time, have been the basis of the work.

Puccinia Stipae Arth. has been grown upon nine different Cichoriaceous and Carduaceous genera, *P. Andropogonis* Schw. upon eight species of hosts belonging to two genera, and *P. Agropyri* E. & E. upon four host genera.

The telial stages are reported for *Aecidium roestelioides* E. & E., *A. Allenii* Clint., *A. Phaceliae* Peck, *A. Onosmodii* Arth., and *A. Liatridis* (Webb.) Ellis & And.

Interesting or new aecial hosts have also been found for *Uromyces Junci* (Desm.) Tul., *Pucciniastrum pustulatum* (Pers.) Diet., *Puccinia amphigena* Diet., and some other species.

A new Cronartium on Orthocarpus is described.

Biologic forms of Puccinia graminis on wild grasses and cereals. A preliminary report. E. C. STAKMAN AND F. J. PIEMEISEL

Biologic forms of *Puccinia graminis* Pers., have been found to infect cereals and grasses as indicated in the following summary.

P. graminis tritici Erikss. and Henn.: wheat, barley, *Hordeum jubatum*, *H. spartinum*, *Elymus canadensis*, *E. virginicus*, *E. robustus*, *Agropyron occidentale*, *Bromus tectorum*, *Hystrix patula*. Rye can be attacked weakly. *Agropyron caninum*, *A. tenerum* and *A. cristatum* have been infected in the greenhouse, and the rust has been found on the first two in the field, but it is not yet known whether it occurs on them commonly.

P. graminis secalis Erikss. and Henn.: rye, barley, *Hordeum jubatum, H. spartinum, Elymus canadensis, E. virginicus, E. robustus, Agropyron repens, A. tenerum, A. occidentale, A. caninum, A. cristatum, A. imbricatum, Bromus tectorum* and *Hystrix patula.*

P. graminis avenae Erikss. and Henn.: oats, *Avena fatua, A. elatior, Anthoxanthum odoratum, Holcus lanatus, Phalaris canariensis, Koeleria cristata, Dactylis glomerata* and *Bromus tectorum.* This form has also quite consistently weakly infected the following: barley, *Elymus canadensis, Lolium italicum, L. perenne* and *Festuca elatior.*

Barley and some of the grasses serve equally well as host for more than one biologic form, thus probably explaining the apparent capriciousness of the rust on certain wild grasses. The classification differs slightly from that made for cereals by Eriksson in Europe and Freeman and Johnson in this country. *P. graminis hordei* F. and J. is not used, and barley is added as a congenial host for *P. graminis tritici* Erikss. and Henn.

There was sometimes a difference in the virulence of the same biologic form when isolated from different hosts, but it was never sufficient to warrant considering the rusts distinct biologic forms. This was particularly true since the virulence of the same biologic form on the same host varied with weather conditions and the condition of the host plant.

Numerous and repeated attempts have been made to change the parasitism or increase the host range of the various biologic forms by means of so-called bridging hosts. Contrary to the earlier experience of some investigators, up to the present time all attempts made by the writers have been unsuccessful. Neither has it been possible to rapidly increase the virulence of a rust strain on an uncongenial host by confining it to that host for a considerable period of time. The biologic forms, when isolated in pure form, have so far remained sharply fixed.

Relationship of the genus Kuehneola. J. C. ARTHUR

The affinities and autonomy of the genus Kuehneola have often been discussed. Argument is now presented to show that it belongs to the Melampsoraceae, among that shifting group of genera: Phakopsora, Schroeteriaster, Bubakia and Physopella. The genus has heretofore been associated with the aecidiaeceous genus, Phragmidium, from which genus it was originally segregated. A few species are considered still to have such affinity, and these are placed under a new generic name.

Relation between storm and disease, August and September, 1915, in Texas. FREDERICK H. BLODGETT

The Gulf storm of August 16 to 19 in Texas was characterized by an exceptionally heavy rainfall and by an unusually prolonged period of continued high wind. This resulted in correspondingly severe losses to the farmers with especial reference to the cotton crop which was just ready for the first picking. The impact of the rain driven by the high winds killed the foliage, but where rains followed later the same week new growth promptly replaced the blasted leaves. About two weeks after the storm complaints became numerous concerning the condition of the cotton bolls in the field, and specimens of anthracnose and bacterial spot were received in considerable numbers. A field inspection trip was made to determine the degree of injury wrought by the combined influence of storm and disease, and it was found that the area of most severe damage was within the region of greatest storm activity, and was practically bounded by the line denoting two inches of

rain falling during the twenty-four hours of the storm. A map has been prepared to show the coincidence of these areas, using the data of the weather service as to the storm factors.

Hard rot disease of gladiolus. L. M. MASSEY

During the last four years the writer has worked with a corm rot of the gladiolus. The corms become infected in the field. The rot advances during storage until by spring many corms are converted into hard, dry mummies. The lesions appear as small, olive brown, water-soaked areas. As the disease advances the infected area becomes sunken and very hard.

Although many isolations of the causal organism were made, and its pathogenicity established, no spore form of the fungus was observed until October 1914. In examining a culture of the fungus, Septoria-like spores were found. Mature pycnidia were then obtained by inoculating the foliage of large plants with mycelium isolated from a diseased corm. The writer had previously noticed the similarity of the mycelial growth of this fungus to that of *Septoria Gladioli* Passer. which was thought to occur only on the foliage of the gladiolus. Further investigation has shown these two organisms to be identical, and that to *Septoria Gladioli* Passer. must be ascribed the cause of the hard rot disease of the corm.

Steaming of soil for the control of root rot of ginseng. J. W. BRANN

Results obtained at Antigo, Wisconsin with steaming of soil indicate that this method is at least partially effective in controlling the brown root rot or "rust" of ginseng.

The inverted pan process as described by Gilbert was followed with such modifications as were necessary. Stratified seed and roots of various ages were planted following the soil treatment in the fall of 1914. Care was taken in selecting healthy roots for planting. Observation of the ginseng beds during the summer of 1915 showed that the plants in the steamed beds not only had less rot, but were more vigorous than those in the control beds.

The physical condition of the soil was improved and this, no doubt, was an important factor in causing the increased vigor of the plants. Weeds were also held in check. More satisfactory results were obtained with light loam than with the heavier soils.

Comparative tests showed that from the standpoint of simplicity, cost of operation and effectiveness, this process is far superior to soil treatment with formaldehyde solution for control of ginseng brown root rot.

Additional benefits from steaming in controlling other diseases of ginseng may be derived.

A wilt disease of the columbine. J. J. TAUBENHAUS

As far as can be ascertained from literature, no Sclerotinial disease is reported to occur on the columbine. A very serious wilt disease was found in the spring of 1913 on a columbine plantation at the flower garden of the Delaware College Experiment Station. The trouble in this case was directly introduced with the manure which was used as a mulch around the plant the previous winter, and which was not removed in the spring. The fungus causing the disease attacks the crown, then the stem and causes a gradual wilting and drying of the plant. The roots are not affected. Pure cultures of the fungus were obtained and the disease reproduced artificially on healthy columbine plants grown in the greenhouse. The sclerotia of the fungus were obtained in large numbers from the interior of dead vines. These

were wintered over in the usual way, and the perfect stage produced. The measurements of these asci and ascospores and the pure cultures from the latter agreed with the description of *Sclerotinia libertiana* Fckl.

Fourth progress report on Fusarium resistant cabbage. L. R. JONES

The previous reports (PHYTOPATHOLOGY **4**: 404, etc.) have shown the high resistance of certain selected Hollander cabbage strains when grown in Wisconsin. Trials on the same "sick" soils in 1915 confirmed these results, although the cool summer gave less yellows than 1914. Even more significance attaches to the cooperative trials made under the auspices of the United States Department of Agriculture in other states; in Delaware under Manns, in Ohio under Selby and Humbert, and in Iowa under Fitch. All showed that selected Wisconsin-grown seed retained its resistance to yellows when grown elsewhere. Mann's observations indicate a possible resistance to Phoma wilt also. Over one hundred pounds of seed of the resistant strains was grown in Wisconsin this last summer, of which twenty-five pounds is of the best head strain "Wisconsin Hollander No. 8." Parties in other states wishing to make trial of this in 1916 should apply promptly for seed. It should be noted, however, that, although the cabbage Fusarium is widespread in the United States, the practical usefulness of these selected Hollander strains is probably limited to the northern states unless it be as a parent stock for further breeding or selection. Middle and southern states require earlier varieties. Selections have been made to meet these needs and will be continued in cooperation with the above named state and national officials. The most promising new thing tried this year is a selected headstrain of Brunswick, a favorite Wisconsin kraut cabbage. This gave on "sick" soil 18 per cent yellows, 100 per cent stand, and 95 per cent heads, while commercial controls alongside gave 84 per cent yellows, 85 per cent stand, and 76.1 per cent heads. Further selections from this and other kraut and earlier varieties have been sent south along with selections by the other cooperating parties for an attempt at seed growing this winter in the hope thereby to save a year's time.

A new method of testing for wilt resistance and for selecting wilt resistant strains of tomato. C. W. EDGERTON

To test the wilt resistant qualities of a variety or to select wilt resistant individuals, it has been necessary, in the past, to grow a large number of individuals in the field. A new method for tomato wilt has been devised whereby the tests and selection work may be conducted in the seed-bed, thus saving considerable time and labor. The soil in the seed-bed is first sterilized by heat and then heavily inoculated, just previous to planting the seed, with pure cultures of the wilt fungus. Susceptible plants growing in seed beds treated in this manner will succumb with the wilt disease from three to eight weeks after planting, while plants in unsterilized soil will not be appreciably affected until after planting in the field. This method is very serviceable for testing the comparative resistance of different varieties, for testing the comparative virulence of different strains of the pathogene, for testing the effect of different soils and fertilizers on the disease and for selecting wilt resistant plants in breeding work.

A newly noted Phyllosticta on alfalfa in America, and its ascigerous stage. FRED REUEL JONES

During the past two summers a yellow leaf blotch disease of alfalfa has been under observation in fields about Madison, Wisconsin, and has been noted in Indiana,

Illinois, Minnesota, South Dakota, and Iowa. The blotches are elongate in the direction of the veins, of a pale yellow color on young leaves, and become deep orange on older leaves. In the infested tissue are constantly found numerous pycnidia of a fungus which appears to be *Phyllosticta Medicaginis* Fckl. Repeated attempts to germinate the conidia, or to infect healthy plants with them have been unsuccessful.

During the past autumn it was observed that the dead leaves on plants which had been infested with this Phyllosticta earlier in the season turned dark, curled up in a characteristic manner, and bore on the under surfaces abundant apothecia of a discomycete which appears to be *Pyrenopeziza Medicaginis* Fckl. Ascospores discharged from these germinated readily. Alfalfa leaves were inoculated repeatedly with the discharged ascospores. The characteristic yellow blotches with abundant pycnidia developed uniformly. Leaf fragments cut from these blotches, sterilized superficially, and placed in culture tubes on suitable substrata have developed the Pyrenopeziza.

These results, and evidence obtained from studies now in progress, indicate that the Phyllosticta is the conidial stage of the Pyrenopeziza.

The development of Mycosphaerella pinodes in pure culture. R. E. VAUGHAN

In connection with pea blight studies carried on at Wisconsin since 1911 *Ascochyta Pisi* Lib. and *Mycosphaerella pinodes* Stone have been constantly associated with diseased vines. In field and greenhouse experiments plants inoculated with Ascochyta have developed this fungus and later Mycosphaerella has been found on the same lesions. Plants inoculated with Mycosphaerella have also developed Ascochyta and Mycosphaerella.

The ascogenous stage of the fungus has now been produced in pure culture under the following conditions. A single spore of *M. pinodes* was isolated by the Keitt method and planted on potato agar. From this culture the perfect stage of the fungus has been again secured by two methods as follows: (1) Transfers were made to green pea leaves which had been sterlized in corrosive sublimate, washed in sterile water and placed in a sterile condition on freshly poured plates of potato agar. Temperature 20°C.; growth rapid and profuse; pycnidia with spores developed on leaf and surrounding agar. After 30 days black perithecia were observed scattered among the pycnidia on the leaf but not on the agar. These contained asci and spores of *M. pinodes*. (2) Transfers to tubes of potato agar were held at 20°C. for 30 days and 11°C. for the next 110 days. Examination then showed them to contain fruiting bodies of both Ascochyta and Mycosphaerella.

Leaf smut of timothy. GEO. A. OSNER

Leaf smut of timothy, caused by *Ustilago striaeformis* (West.) Niessl, has been very abundant in the timothy fields of New York and northern Indiana during the past two seasons. Out of a large number of meadows examined in several different counties, not one was found entirely free from the disease, the loss varying from very slight up to 30 per cent. In Genesee County, New York, where the most complete survey was made, the loss in 1915 was estimated to be about 4 per cent.

During the summer of 1914 several series of inoculations were made to determine the manner of infection. The following methods were tried: (1) inoculating the seed with spores, both fresh and old; (2) inoculating the blossoms; (3) inoculating the soil and sowing seed after varying lengths of time; (4) inoculating growing tissues directly. Where the checks remained healthy, infection occurred only in the case of blossom inoculation.

Experiments have been conducted on the control of this disease by seed treatment with formaldehyde solution, copper sulfate solution, and hot water. The formaldehyde and copper sulfate solutions failed to control the disease but perfect control was obtained by means of the hot-water treatment.

Some root diseases of the bean. W. H. BURKHOLDER

An investigation of a serious disease of the bean (*Phaseolus vulgaris*) in western New York was undertaken during the summer of 1915. The disease is manifested, principally in a yellowing and dropping of the leaves, and a failure to set pods. Examinations show that this trouble is due to an affection of the roots and of the stem underground. A week or so after the bean plant has appeared above ground a discoloration of the tap root is noticed. The disease spreads slowly, killing the lateral roots, the lower ones first and extending in red streaks a short distance up the stem. A great many surface roots are developed above the diseased area. A field of beans which gives promise of a fair yield in July, may prove a failure at harvest time.

The trouble is due to several causes, the primary one being a species of Fusarium which attacks the underground parts. *Thielavia basicola* was found generally upon the bean root and in a number of cases, Rhizoctonia was found.

Inoculation experiments gave positive results with all three organisms, a somewhat different lesion being formed by each.

Inoculation experiments with the Fusarium upon the various crops grown in rotation with the bean all gave negative results. The pea (*Pisum sativum*), red clover (*Trifolium pratense*), alsike (*Trifolium hybridum*), and alfalfa (*Medicago sativa*), proved susceptible to *Thielavia basicola*. The species of Fusarium seems to be distinct from any that has been described previously on the bean.

Two interesting diseases on greenhouse tomatoes. MEL. T. COOK AND C. A. SCHWARZE

A leaf spot on greenhouse tomatoes has been studied. The trouble originates as small circular spots which enlarge, become grayish brown and show concentric, somewhat irregular circles very similar to *Macrosporium Solani*. Small, blackish pustules, visible under the hand lens, exude whitish strings of spores. The fungus corresponds with the description of *Ascochyta Lycopersici* recorded by Saccardo on weakened plants in Italy and in France. Puncture inoculations from cultures reproduced the typical disease. It is evidently a weak parasite.

A fruit rot was first observed on ripe and semi-ripe fruits, starting at the blossom end. The diseased fruits were soon covered with a dense grayish mass which proved to be a Botrytis. This rot was very generally restricted to fruits with a rough or creased blossom end and rarely occurs on smooth fruits. A further study showed that the old blossoms so commonly found clinging to the fruits usually contained the fungus. Fruits from which the corollas dropped early were rarely affected. When drops of water containing the spores were placed on the rough blossom end fruit, the rot developed very quickly. The same test with smooth tomatoes seldom gave a rot unless the epidermis was punctured. Dead blossoms placed on the rough blossom end of fruits and kept moist also gave the rot. In cultures the fungus produced large, black sclerotia. The symptoms are practically the same as have been described for blossom end rot.

Cucumber diseases in the middle west. W. W. GILBERT

An investigation of the cucumber diseases was begun the past season in Wisconsin, Indiana, and Michigan, in cooperation with the state experiment stations.

Extended observations during the past season in these and adjacent states brought out the following facts regarding cucumber disease occurrence.

The cucumber mosaic disease, commonly called white pickle, has been found causing serious losses in the states of Wisconsin, Michigan, northern Indiana, and Illinois, and is known to occur also in Iowa, Ohio, Vermont, New York, Minnesota, Massachusetts, and Virginia. This disease is comparatively new in its serious occurrence in the field and is being studied from the field standpoint by Mr. S. P. Doolittle of the Michigan Agricultural Experiment Station. Prof. I. C. Jagger, of Cornell University, has also been studying the disease as it occurs in the greenhouses in Rochester, New York. A description of the disease and a record of results of the preliminary work which has been done will be given elsewhere.

The scab (*Cladosporium cucumerinum*), caused quite serious losses to pickle growers in Michigan and occurred in a more limited way in Wisconsin, Indiana and Ohio.

Anthracnose (*Colletotrichum lagenarium*), occurred quite generally over northern Indiana, Wisconsin, and southern Michigan and did considerable damage, owing to the favorable conditions incident to a wet season.

The wilt disease (*Bacillus tracheiphilus*), occurred quite generally in Wisconsin, Indiana, and Michigan in the early part of the season but has not been considered a very serious trouble by pickle growers for the reason that most of the injury is done before the final thinning of the plants.

The angular leaf spot, a new and undescribed bacterial disease, which is now being studied by Mr. Eubanks Carsner in Wisconsin, occurred particularly in Wisconsin and central Michigan and in some cases caused serious defoliation of plants in affected fields.

Downy mildew (*Peronoplasmopara cubensis*) did practically no damage this season as it did not appear in northern Indiana until a few days before the cucumber plants were killed by frost.

A new infectious mosaic disease of cucumber. S. P. DOOLITTLE

To be published in full in the April issue of Phytopathology.

Experiments with the cucumber mosaic disease. I. C. JAGGER

To be published in full in the April issue of Phytopathology.

Angular leaf spot, a bacterial disease of cucumbers. EUBANKS CARSNER

A leaf spot disease of cucumbers, proved to be of bacterial origin, has been a subject of study in Wisconsin and elsewhere during the past two seasons. The disease is characterized on the leaves by rather sharply angular spots bounded by the larger veinlets. The spots have at first a watersoaked appearance and later become brown. Old diseased leaves often show a ragged appearance following the breaking away of dead parts. On both surfaces of affected areas, under moist conditions, a slightly viscous exudate containing bacteria has been repeatedly observed which, on drying, leaves a white residue. The disease often appears also as longitudinal lesions on the stems. The only similar disease which has been noted in literature is that described by O. F. Burger from Florida as a bacterial rot of cucumbers.

The angular leaf spot disease is widespread and destructive. The writer has observed it in Wisconsin, Virginia and Michigan, and has seen specimens of it from Illinois, Indiana and Iowa.

The causal organism has been isolated, used in pure culture to produce the characteristic disease and has been reisolated. It is rod-shaped and motile. The flagella are polar.

From preliminary experiments the disease seems to be held in check by spraying with bordeaux mixture.

Studies in the control of storage rots of the sweet potato. J. J. TAUBENHAUS

Careful investigations have shown that soft rot (*Rhizopus nigricans* Ehr.) is the greatest detriment to the keeping of sweet potatoes in storage. The losses from this disease run from 5 to 60 per cent. Next in importance is black rot (*Sphaeronema fimbriatum* (Hals.) Sacc.). The losses from this disease are comparatively small. The factors which favor soft rot are poorly ventilated houses. Rough handling of the crop at digging and storing as well as moist warm weather are also factors which interfere with proper keeping. These are conducive to soft rot. Overheating and lack of ventilation favor black rot. Storage men are beginning to realize the advantages of ventilation. Careful studies have shown that the average sweet potato house is poorly built and has poor facilities for ventilation. Hygrothermographic studies have shown that a relative humidity of over 70° in storage is detrimental. At present all types of houses good or poor depend on natural ventilation, hence the storage of sweet potatoes is precarious. Soaking the sweet potatoes with various strengths of copper sulphate, corrosive sublimate or formaldehyde proved ineffective in controlling the storage rots. Fumigation with sulphur and formaldehyde have not given results; however, the average sweet potato house is not tight enough to retain the fumes. It was apparent in previous studies that artificial ventilation and drying under moist and adverse weather conditions must be resorted to. An electric fan has been installed in one of the large commercial houses which offers an economical means of ventilation. Whether such an artificial system aided by heat from stoves will carry sweet potatoes through adverse conditions is to be determined.

Field studies on the Rhizoctonia of the potato. MEL T. COOK AND H. CLAY LINT

The Rhizoctonia disease of potatoes was very severe in New Jersey in 1915, causing (1) poor germination, (2) brown stem, (3) curly leaf (4) dwarfing, (5) aerial potatoes, (6) little potatoes, and resulting in (1) poor stands, (2) reduced yields and (3) in some cases complete loss of the crop. The severity of the attack varied with seed from different sources as shown by field observations and planting on the Experiment Station farm. The results from seed treatment were variable but the corrosive sublimate was much better than treatment with formaldehyde.

A Fusarium tuber and stem rot of potato. R. J. HASKELL

During the past year the writer has isolated, from the fibrovascular bundles of potato tubers, a Fusarium which produces a very virulent stem and tuber rot.

After making sure that the cultures were pure, potato plants were inoculated by injecting, or inserting, spores and mycelium into the stems just below the level of the ground. Fifty plants both in the greenhouse and in the field, were inoculated and of these 80 per cent became affected. The tops wilted and died because of the rot at the base. Many of the potatoes from inoculated plants showed the characteristic rot in the region of the vascular ring, and some of them had a sunken, dry, stem-end rot. In no case did the checks show any of these symptoms.

The Fusarium apparently belongs in the section Martiella Wr. and is closely related to, if not identical with, *F. eumartii* Carpenter. It resembles the latter very much in its ability to rot potatoes in storage.

Infection and resistance studies of Phytophthora infestans on the tomato. I. E. MELHUS

Tomato foliage is readily infected with *Phytophthora infestans* of the Irish potato, but it has not been found possible to infect the fruit except through the peduncle, the calyx, or the epidermis when ruptured. Indeed when the epidermis of the fruit is intact, infection does not take place. The period of incubation is the same for the tomato and the potato, that is from three to six days, depending on moisture and temperature conditions. The fungus spreads and fruits more sparingly on the foliage of the tomato than on the foliage of susceptible varieties of potato, and to this fact are doubtless due the numerous contradictory statements relative to the identity of species of Phytophthora on these two plants. Livingston's Coreless and Carter's Sunrise tomatoes are susceptible, but less so than Green Mountain or Irish Cobbler, which are among the most susceptible varieties of potatoes. The Red Peach potato is very highly resistant, in fact more so than any of the specially resistant German varieties of potatoes, e.g., Apollo and Sophie.

Meteorology and late blight of potatoes. C. R. ORTON

The late blight of potatoes caused by *Phytophthora infestans* destroyed nearly one-half of the potato crop in Pennsylvania the past season. It has now been reported at State College and vicinity in 1891, 1910 and 1915. Of these seasons it was least destructive in 1910.

A study of the meteorological conditions which might permit an outbreak of late blight at State College appears to show that precipitation alone has little if any bearing on the problem. Neither do atmospheric temperatures alone or when correlated with precipitation appear to show much relation to outbreaks of Phytophthora.

Other factors which do appear to bear more directly on the subject are humidity and soil temperature. Low soil temperatures which approach the optimum temperature for the rapid development of Phytophthora in artificial cultures, are thought to be of importance in initiating an outbreak of late blight. High relative humidity the latter part of July and in August is possibly the most important factor in determining the rapid spread of Phytophthora to produce an epiphytotic.

The morphology and cytology of the sexual organs of Phytophthora erythroseptica. PAUL A. MURPHY

A study of sectioned and stained material has shown that the development of the sexual organs follows the course described by Pethybridge, the oogonial incept growing through the antheridium and forming the oogonium at the other side.

The incept has been found in the act of penetrating the antheridium, and numerous stages have been seen in the process of emergence and in its further development into an oogonium. The antheridium remains permanently clasping the stalk of the oogonium.

Meantime the greater number of nuclei in both organs have degenerated. The remainder divide once, mitotically and simultaneously. Immediately afterwards the cytoplasm of the oogonium is differentiated for a short time into ooplasm and periplasm with all the daughter nuclei lying on the line separating the two.

Fertilization takes place at this stage. A tube is pushed in from the antheridium

through that part of the stalk of the oogonium which lies within the male organ, and through it a single male nucleus and the greater part of the cytoplasm passes in.

The periplasm is absorbed before the wall of the oospore thickens, and fertilization is then completed by the fusion of the single male and female nuclei.

The effect of bordeaux mixture on the potato plant. B. F. LUTMAN

There seems to be a general agreement among all experimenters who have used bordeaux mixture on the potato in the northern states that the effects are beneficial to the plant. The European results are not always in accord with the American. From seven years trial in this country and from one in Germany, the author believes that the beneficial effects of the bordeaux can be ascribed to its prevention of: (1) The early appearance of tip-burn, (2) the greater part of the flea-beetle injuries.

Of these two effects, the former is much the greater. In spite of an increased general transpiration in the sprayed plants, the advance of the tip-burn is much slower than in the unsprayed ones. The cause of this retardation seems to lie in some sort of chemical union between the chlorophyl and the copper compounds. Sprayed plants unaffected by tip-burn do not produce more starch per plant than similar unsprayed ones.

Spongospora on the roots of the potato and on seven other new hosts. I. E. MELHUS AND J. ROSENBAUM

Spongospora is commonly considered a tuber disease, but in certain greenhouse experiments in 1914, involving the use of infected soil it was found that galls developed generally on all underground parts of the potato plant, and on August 5, 1915, this condition was found to prevail in the field also. In the latter, it was found during the past season that fifty-seven days elapsed between planting and the first sign of infection. Where plants about half grown were transplanted from clean to infected land infection resulted in from fourteen to thirty-four days. The galls occur first on the very small rootlets, but later on are in evidence on the larger roots also. As many as two hundred and fifty galls have been found on the under ground parts of a single potato plant. The present investigation has shown that Spongospora has seven hosts besides the potato, that is, the tomato and six species of Solanum. The galls are much larger on some of these hosts than on the potato. The new hosts are as follows: *Solanum commersoni*, *S. ciliatum*, *S. marginatum*, *S. mammosum*, *S. haemotocladum*, *S. warscewiczii*, and *Lycopersicon esculentum*.

Two wild hosts of Bacterium solanacearum. H. R. FULTON AND E. E. STANFORD

On land known to be infested with *B. solanacearum*, plants of *Ambrosia artemisiæfolia* L. and *Eclipta alba* (L.) Hassk. showed characteristic symptoms of the bacterial wilt or brown rot of Solanaceae. From these hosts a bacterium was isolated in pure culture, which, when inoculated by needle pricks, produced the disease on Ambrosia, Eclipta, tomato, tobacco, and nasturtium. The organism was reisolated from artificially inoculated plants and its identity with the inoculum proved.

Comparisons of strains of the bacterium from Ambrosia, Eclipta, tobacco, tomato and peanut showed agreement in cultural characteristics on various media. The reactions to ordinary stains were the same. The organism agrees in all essential respects with *Bacterium solanacearum* Erw. Sm.

Eclipta alba is susceptible and *A. artemisiæfolia* very resistant to this bacterium. Constant differences in virulence were apparent in strains of the organism isolated from different species as well as in those isolated from different individuals of the same species.

Life histories of Melanops. C. L. SHEAR AND MISS A. M. BECKWITH

Melanops from the following thirteen hosts have been grown in pure cultures from single ascospores and have produced pycnidia: *Aesculus hippocastanum*, *Cercis canadensis*, *Crataegus* species indet., *Juglans cinerea*, *Liquidambar styraciflua*, *Pyrus malus*, *Quercus* two species indet., *Ribes rubrum*, *R. oxyacanthoides*, *Robinia pseudacacia*, *Viburnum* species, and *Vitis labrusca*.

The cultures from Aesculus, Cercis, Juglans, Liquidambar, Pyrus (one collection), Ribes, both species, Robinia, and Viburnum produced Dothiorella micro- and macropycnospores.

The cultures from Crataegus, Pyrus (two collections), Quercus, two species, and Vitis gave Sphaeropsis of the *S. malorum* type.

In two instances, one from currant, *Ribes rubrum* and one from Viburnum, asci and ascospores, as well as pycnospores, have been produced in pure culture from single ascospores. One form from currant is chromogenic on certain media, as starch-paste and cornmeal, as has been described by Grossenbacher. A form from Viburnum is also chromogenic.

The taxonomic status of the organisms on the different hosts has not yet been satisfactorily determined. All of them are very similar morphologically and some of them have been referred to by the senior writer previously as forms of *Melanops quercuum* (Schw.) Rehm.

The perfect stage of Septoria ribis. R. E. STONE

As the result of three season's work the author has come to the conclusion that *Mycosphaerella grossulariae* (Fr.) Lind., is the perfect stage of *Septoria ribis* Desm.

The conclusions are based upon the following data:

Leaves of *Ribes nigrum* L., infected with *Septoria ribis* Desm., bear in the following spring and early summer an ascomycete which agrees with the descriptions of *Sphaerella grossulariae* (Fr.) Auserw., as given in Saccordo's Sylloge Fungorum and other works. It also agrees with *S. grossulariae* (Fr.) Auserw., on *Ribes nigrum* issued by Sydow as No. 581 Myc. Germanica.

The ascospores of the fungus found here, when planted singly in culture media give rise to colonies of Septoria. This Septoria, when sprayed upon the leaves of *Ribes nigrum* L., gives rise to typical leaf spots bearing typical pycnidia and spores of *Septoria ribis* Desm.

If leaves of *Ribes nigrum* L., are inoculated directly with the ascospores of the fungus, typical lesions and fruit bodies of the Septoria are formed.

In addition *Ribes rubrum* L., and *Ribes oxycanthoides* L., can be infected with the ascospores derived from the old leaves of *Ribes nigrum* L., and also by the Septoria spores either taken directly from the leaves of the black currant or derived from cultures resulting from germinated ascospores.

Ribes aureum Pursh does not seem to be susceptible to this particular Septoria.

Ascospore material has been collected at Guelph, Ontario, 1913, 1914, 1915, and by Mr. McCubbin of the Dominion Laboratories and the author at St. Catherines, Ontario, in 1915.

The only previous collection of *Sphaerella grossulariae* (Fr.) Auserw., in America on record is that by Professor Pammel in Iowa and reported in Bul. Iowa Agr. Exp. Sta. 13: 70. 1891.

Phytophthora rot of apples. H. H. WHETZEL AND J. ROSENBAUM

Published in full in this issue.

Black root-rot of apple. H. R. FULTON AND R. O. CROMWELL.

This rot has been observed in serious degree at a number of points in Pennsylvania and North Carolina. The fungus causing it produces a dense superficial growth of mycelium that is at first white and later becomes a black incrustation. It grows readily on ordinary culture media. There is only a slight tendency towards rhizomorphic development. Spinulose terminals of the hyphae are characteristic. There are hyphal anastomoses. No spore production has been observed under either natural or artificial conditions. Pure cultures of the fungus readily produce characteristic rotting when introduced into bark wounds of apple roots. This rot may extend fourteen inches in twelve weeks, the spread being about equal distally and proximally from the point of inoculation. The bark is killed throughout, and the fungus threads penetrate the wood rendering it brittle. Complete disintegration is slow.

The fungus shows points of difference from those ordinarily recognized as root destroying forms. Its identity has not yet been determined.

Blister spot of apples. D. H. ROSE

During the summer of 1915 what seemed to be a new disease was observed on Early Melon, Ishewold and Hawley apples and on one variety in an orchard of French Dwarf apples. The disease consists of roughly circular, sometimes irregularly lobed shallow blisters varying in color from light brown to black and in size from one to five millimeters in diameter by one-half millimeter in depth. Poured plates from blisters on all the affected varieties gave after thirty-six hours nearly pure cultures of a motile rod 0.9 to 2.7 by .5 to .8 μ. Colonies were pale white, usually about one millimeter in diameter. Free hand sections of blisters showed the organism present in large numbers in ruptured cells of the epidermis and the tissues immediately beneath it.

Throughout thirty series of cultures the writer found the following reactions consistently repeated: litmus milk turned blue in three days, then slowly decolorized from the bottom upward, casein slowly precipitated then gradually redissolved; gelatine liquefied after six or seven days; growth on potato moist, spreading, cream colored; acid from dextrose and saccharose, but none or very little from lactose, and no gas from any of them; fermentation results are from three tests only.

Inoculation by needle punctures gave typical blister spots in about two weeks on Early Melon, Ishewold, Yellow Newton and Jonathan. From these spots an organism was recovered, which, judging by its morphology, and cultural characteristics was identical with the one used for inoculation. Reinoculation with this second isolation again produced typical spots.

The investigation is being continued.

Apple scald. CHARLES BROOKS AND J. S. COOLEY

Experiments in progress indicate that humidity is more important than carbon dioxide in determining the amount of scald. Apples have been stored in unstirred atmospheres containing various percentages of carbon dioxide without the development of scald, while similar apples kept in saturated atmospheres in closed but unsealed moist chambers became badly scalded. Others kept open in stirred atmospheres of 40 per cent to 70 per cent relative humidity have not scalded. Neither

have others kept open in a stirred atmosphere in which the carbon dioxide was kept at 1½ per cent to 2 per cent. Apples have scalded more quickly at high than at low temperatures.

The results suggest the importance of cool temperature, and an open pack in the prevention of scald.

Irrigation and bitter pit. CHARLES BROOKS AND D. F. FISHER

A sort of corky pit is produced on the fruit of trees that have suffered from a sudden check in the water supply. The corky pit differs from true bitter pit in having much larger areas of dead brown tissue and in usually appearing earlier in the season. At first the spots are watersoaked and of irregular shape, often a reddish color, and usually give off drops of a yellowish sticky liquid that is sweet to the taste. In late stages of the disease the fruit is much misshapen, the spots hard and sunken and the flesh beneath the skin brown and corky like that of an old bruise.

True bitter pit increases with an increase in the irrigation water. Heavy applications late in the season have been especially harmful. The following results were obtained on Grimes Golden apples, the counts being made twelve days after picking:

Irrigation	*Per cent. of bitter pit*
Heavy throughout the season	43
Medium throughout the season	17
Medium until August, then heavy	49
Light throughout the season	14

Similar results have been obtained on Jonathans and other varieties.

Temperature relations of apple rot fungi. CHARLES BROOKS AND J. S. COOLEY

Apples with natural infections of bitter rot and black rot were stored at various temperatures. The development of bitter rot was slow at 15° C., rapid at 25°, and slow at 30°. It was completely inhibited at 0°, 5°, and 10°, but after two months' exposure to these temperatures developed rapidly when removed to 25°. Black rot developed rapidly at 25°, but at the end of ten days had made but little progress at 10°. After two months' time it had made considerable development even at 0°.

Apples were inoculated with various fungi that had been isolated from decaying fruit. In two weeks' time little or no rot had developed with any of these at 0° or 5°. Monilia had made a very rapid growth at 10° and *Penicillium expansum* a medium growth. Botrytis had made a good growth at 15° but little at 10°. Sphaeropsis, Glomerella, Alternaria, and Cephalothecium had made but little development at 10° and 15°, but had grown rapidly at 20°. Neofabraea, Volutella, *Fusarium radicicola* and *Pestalozzia funerea* made but little growth at 15° and only a fair growth at 20°.

In flask cultures the growth of the above fungi, as shown by dry weight, was closely parallel to that on the fruit.

Brown blotch of the pear. G. W. MARTIN

This disease, which causes a serious disfigurement of the pear, has been present in orchards of New Jersey for a number of years, but because of its resemblance to the russeting which is a characteristic feature of many pears belonging to the Oriental group, has not been recognized as a pathological condition. The fact that the disease is readily controlled by spraying seemed to indicate that it was of parasitic origin and further study showed its constant connection with a fungus apparently

identical with one described under the name *Macrosporium Sydowianum* Farneti as causing a similar disease in Italy.

The direct damage is confined to the epidermal layers of the fruit. Besides the unsightly appearance of the diseased fruit, its keeping qualities are seriously impaired, and in the more severe cases scabby growths and deformities result.

The disease is readily controlled by two late treatments of spray.

A preliminary report on investigations of leaf spot of cherries and plums in Wisconsin. G. W. KEITT

During the past season, a field laboratory was maintained at Sturgeon Bay for studying certain leaf diseases of cherries and plums.

Cylindrosporium spp. were found to be the most seriously injurious leaf parasites of *Prunus* spp. in the sections studied. Cylindrosporiums were isolated from cultivated cherries and plums and from numerous wild species of Prunus. The relationships of these fungi to the various hosts and to one another are being studied.

Especial attention was devoted to a study of the life history of *Coccomyces hiemalis* Higgins in relation to the course and the prevention of leaf spot of sour cherries. Ascospores were found to constitute the source of primary infection. They were produced in great abundance upon the overwintered leaves on the ground. No evidence of discharge of ascospores was observed under field conditions until most of the petals of *P. cerasus* had fallen. Subsequently, under favorable conditions they were discharged abundantly throughout the spring and early summer. The disease was satisfactorily controlled on sour cherry trees which received their first application of spray when the petals were three-fourths off. Similar unsprayed trees were practically defoliated. Field observations strongly indicate that, under Wisconsin conditions, it is feasible greatly to reduce primary infection by early spring plowing and the disposal of leaves on the unturned soil about bases of trees before ascospores are liberated.

A convenient little-known method of making micro mounts of fungi. F. L. STEVENS

A description and demonstration is given of a modification and adaptation of a celloidin method of mounting fungi described by Gaillard, also used by Buscalioni.

The process consists in placing a drop of 4 per cent celloidin upon the fungus, allowing it to dry, lifting it off with forceps, dehydrating and clearing and mounting in balsam.

The method is particularly adapted to superficial fungi such as the Erysiphaceae, Microthyriaceae, Perisporiaceae. But it is useful also with the Moniliales, Uredinales, and so forth, and in the study of agar plate colonies.

The parasitism of Valsa leucostoma. R. C. WALTON AND D. C. BABCOCK

The seriousness of the disease caused by *Valsa leucostoma* in Ohio in 1915 prompted the writers to conduct a series of experiments with the fungus. Numerous inoculations made with mycelium from culture into peach branches, and peach and plum fruit, resulted as follows: (a) Inoculations made in the trunks and larger branches of living peach trees gave 100 per cent infection. Cankers were formed averaging 2.8 by 1.6 inches in one month's time, with the formation of pycnidia. (b) Mycelium placed over lenticels, without artificial wounds and covered with moist cotton, produced no infection. (c) Peach fruit, both green and ripe, inoculated with mycelium gave 94 per cent infection. (d) Plum fruit inoculated with mycelium gave 97 per cent infection. (e) Inoculations made in tips of peach branches gave 85

per cent infection. (f) Practically as many checks as inoculations were made, and these in all cases remained free.

Exudation of gum was plentiful on apparently healthy peach branches and trunks. Several specimens collected and cultures made from beneath the gum, after sterilizing the surface of the bark, showed that 41.2 per cent were infected with this fungus. Although there are other causes of gum flow, our experiments lead us to believe that many of the gum exudations are incipient infections of this disease.

Bacillus amylovorus in honey and in honeydew. H. A. GOSSARD AND R. C. WALTON

Honey obtained from beehives at various intervals during the spring and summer of 1915 was sterilized and inoculated with *Bacillus amylovorus*. After incubating from 8.5 minutes to several days in both pure and 50 per cent honey, the organism was cultured by the poured plate and streak methods on 3 per cent neutral nutrient glucose agar. One hundred and seventy-six cultures were made and *B. amylovorus* growth obtained repeatedly up to and including 43 hours and 25 minutes after infection. This isolated organism was then inoculated into the growing tips of apple shoots with 100 per cent infection resulting.

A fresh culture of *B. amylovorus* was inoculated into a test tube of unsterilized honey and incubated there for from 4 to 47 hours. At the end of the 4th, 28th, and 47th hour, inoculations were made from the infected honey directly to the tips of apple shoots. These inoculations gave 84, 64, and 52 per cent infection respectively, showing conclusively that the blight organism can remain sufficiently virulent in honey for at least 47 hours to produce infection.

Drops of aphid honeydew on apple leaves were infected with *B. amylovorus*. Inoculations were then made with the honeydew at the end of 20.5 hours, 43 hours, and 71.3 hours into apple shoots, using the infected honeydew as the inoculum. These inoculations gave 66.6, 83.3, and 100 per cent infection respectively.

Reisolations were made in many cases from the diseased shoots previously inoculated, and the indentity of the organism proved by cultures and microscopic examination.

Dusting nursery stock. V. B. STEWART

During the summer of 1915 experiments were conducted to test the relative value of dusting and spraying for the control of a number of leaf diseases of nursery stock. The experiments included the following: *Coccomyces hiemalis* and *Podosphaera oxyacanthae* on cherry; *Guignardia Aesculi* on horse-chestnut; *Pseudopeziza Ribis* and *Septoria Ribis* on currants; *Sphaerotheca pannosa* var. *Rosae* on Crimson rambler. Only a few hundred plants were included in each experiment. Four applications were made for the control of rose mildew. For the other diseases six to seven applications were made. The dusted plats were treated with a dust mixture of ninety parts sulfur and ten parts powdered arsenate of lead. Lime-sulfur solution, one gallon to fifty gallons of water, was used in the sprayed plats. In all cases the dust mixture was as effective as the lime-sulfur solution. The dust mixture was slightly more effective than lime-sulfur on horsechestnut and currant stock owing to the better distribution of the fungicide on the foliage. The results obtained warrant further experiments conducted on a more extensive scale.

Some new strawberry fungi. F. L. STEVENS AND ALVAH PETERSON

Rots of the ripe strawberry caused by several fungi are described and the characters of the fungi both in nature and in pure culture discussed. The following fungi are considered: *Sphaeronemella Fragariae* n. sp., *Patellina Fragariae* n. sp., *Botrytis cinerea*, *Sphaeropsis malorum* and *Rhizopus nigricans*.

Eradication of Cronartium ribicola from European pine plantings in New York State. W. H. RANKIN

Forty-seven plantings out of the original seventy-nine plantings of European white pine in New York have shown no diseased trees. Eighteen of these are now released from inspection as free from the disease. In thirteen no species of Ribes were ever found in the immediate vicinity. The other twenty-nine will be inspected in the autumn of 1916 to see if any trace of the telial stage is to be found on neighboring species of Ribes and then released if found free. Obviously these plantings are no indication of the effectiveness of the eradication methods used.

The thirty-two plantings which have shown diseased trees at some time or other since 1909 are divided into two groups: (1) sixteen plantings showing diseased trees only before 1913, eleven of these in 1910 only, and (2) sixteen plantings showing diseased trees since 1913, twelve of these both before and after 1913 and four after 1913 only. In the sixteen which have been free since 1913, eleven since 1910, eleven showed only either one or two diseased trees. Apparently the inspections and eradication methods have proved effective in eradicating the fungus in these sixteen plantings. However, in the other sixteen plantings, nine have shown an increase in the number of diseased trees found since 1913 and seven a decrease. It is believed that in fourteen of these sixteen plantings the fungus has passed from pine to species of Ribes and back to pine. Evidently the eradication has not been effective in one-half the plantings where there was anything to gain by inspection.

Eradication on a large scale. EDGAR NELSON

The attempt in Florida to eradicate citrus canker, a disease attacking citrus trees and fruit, is unique in plant pathological history because of its magnitude and the drastic methods employed by state authorities in their endeavor to wipe out the most dangerous enemy to citrus culture as yet known.

A year ago plant pathologists doubted the wisdom of the methods adopted by the state in its efforts to eradicate canker. Destruction by fire of trees, some yielding many boxes of fruit each year, seemed too radical a method to follow especially as the disease was a new one and just being studied. However, the discovery by Miss Hasse that the causal organism was a bacterium, *Pseudomonas Citri*, and not the fungus Phyllosticta, only justified this drastic measure. The work of eradication has been continued by the state which is determined to become free of this dangerous disease.

Trained inspectors examine the trees and destroy all infections with fire. Kerosene mixed with crude oil is sprayed on the tree. When this spray is ignited a flame of intense heat soon consumes the tree. Great precautions are taken to sterilize everything employed in infected areas as canker is very contagious.

A Gloeosporium on horse-chestnut shoots. J. F. ADAMS

In May 1915 the writer's attention was called to the blighting of terminal shoots of several horse-chestnut trees, *Aesculus hippocastanum*. Specimens were collected and on examination the shoots were found to be killed back for several inches from the terminal bud. The diseased tissue was somewhat shrunken and the epidermis ruptured by numerous scattered acervuli with conidia of the Gloeosporium type.

Specimens placed in moist chamber developed profuse pinkish exudations of conidia from which pure cultures were procured. Growth in cultures was similar to that usually produced by Glomerella from apple developing numerous scattered

acervuli but no setae were found. Cultures two weeks old developed perithecia and ascospores. Inoculations on apple have produced a typical rot with characteristic development of acervuli and conidia similar to *Glomerella cingulata* with perithecia developing later.

The species differs from *Gloeosporium carpigenum* Cke., the spores of which are described as issuing in whitish tendrils on the fruit of *Aesculus californica*. In this species the spores are smaller and pinkish in mass. Further investigations are under way to establish the degree of parasitism of the fungus.

Inoculation studies with Neofabraea malicorticis. H. S. JACKSON

An extensive series of inoculations on apple trees with cultures from both the conidial and ascogenous stages of *Neofabraea malicorticis* (Cordley) Jackson, derived from apple, pear, and quince were made in the fall of 1913. The cankers developed from these inoculations have been studied through two seasons. The results confirm and extend the previous report of the genetic connection of *Gloeosporium malicorticis* Cordley with Neofabraea, made by the writer at the Washington meeting of the American Phytopathological Society (Dec. 1911) and published in the First Biennial Crop Pest and Horticultural Report of the Oregon Experiment Station (Jan. 1913).

Longevity of Bacillus amylovorus. J. W. HOTSON

On account of differences of opinion among certain fruit growers of the Yakima Valley, Washington, as to the length of time the fire blight organism lives in infected branches after they have been cut off, an effort was made to obtain some information regarding what actually occurs in the orchard. The object of these experiments was to determine how long the organisms live in the dried-up exudate when exposed to the direct sunlight, and also in infected branches when they are thrown down in deep grass or on soil in clean cultivation.

It was found that the organisms existing in the exudate on branches when exposed to direct sunlight on dry sunny days remained alive from ten to thirteen days according to the amount of exudate present. About the same results were obtained when the exudate was on the fruit. In positions where the branch was shaded part of the day, being exposed to direct sunlight about half time and diffused light the other half, the bacteria lived twenty-seven days in the bark. When exuding branches were left on the ground in an orchard, in which clean cultivation is practiced, the living organisms were obtained after fifteen days, while in infected branches left in an orchard where there was a cover crop of alfalfa, living bacteria were obtained in some cases twenty-nine days after the limbs were cut.

Observations on fire blight in the Yakima Valley. J. W. HOTSON

During the summer of 1915 a number of very peculiar conditions were observed in the study of fire blight in the Yakima Valley, Washington:

1. Fire blight on the cherries has already been recorded in the December number of Phytopathology.

2. Fire blight has been shown to gain entrance to the host through the leaves. These infected leaves, mostly Bartlett pears, turn brown in sections, the brown areas always including a portion of the margin of the leaf. The diseased leaves resemble sun scald in appearance.

3. A red streak similar to that found in connection with fire blight has been observed in the sapwood of Comice and less frequently, in Bartlett and Winter Nelis pears. In some instances *Bacillus amylovorus* has been definitely associated with

the streak, the organism, however, never being found near the extremity of the coloration.

4. Fire blight has been found frequently as twig infection on the Yakimine, a cross between a prune and a peach.

5. An abnormal amount of fruit infection was observed, it being out of all proportion to that found on the twigs and trunk. This increase was traced in some orchards to the fresh wounds made in thinning the apples.

A new species of Melanconium parasitic on the tomato. W. H. TISDALE

The disease was first observed in January, 1915, on both green and ripe tomato fruits in the horticultural greenhouse of the University of Wisconsin. It is characterized by small, dark brown to black spots which are largely superficial and not more than one-eighth of an inch in diameter when the fungus does not enter through wounds. In case of wound infection however the invasion proceeds more rapidly and the spots become sunken and are dark brown with concentric markings. A single spot may involve the entire side of a fruit, resembling very much the spots caused by *Gloeosporium phomoides* Sacc., the common tomato anthracnose. The disease is much more destructive to green fruits than the Gloeosporium disease.

The fungus was isolated and grown in pure culture. Inoculations were made on green and ripe tomato fruits both by wounds and by spraying the unwounded surface with a spore suspension. Both types of spots were thus obtained and the fungus was reisolated in pure culture.

On the large, wound-infection spots small, single-celled conidia are produced abundantly in acervuli which break through the cuticle. The fungus fruits very freely on oat meal and tomato agar. Spore masses are black, although a single spore under the microscope transmits light and appears greenish.

The characters of the fungus correspond with those of the genus Melanconium. No record of a species of Melanconium parasitic on the tomato has been found in literature. A large number of species, mostly saprophytic, have been described, but the tomato parasite differs from these so widely in its mycological characters, to say nothing of its parasitic nature, that it appears to be an undescribed species.

Tip-burn in white pine. G. P. BURNS

The forest nursery of the State Forestry Department of Vermont consists of three sections. Sections one and two are located on a sandy plain. Section one is almost wholly unprotected while section two is protected by a board fence and a large white pine grove. Section three is about one-fourth mile distant and is protected on three sides by a high bank on which are large white pine.

In June, 1914, the foreman telephoned that the trees were dying by the thousands and "there will not be a seedling or transplant alive by tomorrow night at this rate." Sections one and two were seared and brown having changed in one day from a healthy green color. A careful examination showed that some of the lower spots in these sections were still green and that section three had not been injured in any way.

The author had one control station fitted with meteorological instruments in operation in section one. The instruments recorded velocity of wind, amount of sunshine, amount of rainfall, air temperature and soil temperature. A study of the data seems to indicate that the velocity of the wind was the deciding factor in killing half of the young leaves. The meteorological data for the week previous to the injury are shown in the chart.

Second progress report on disease resistance in tobacco. JAMES JOHNSON

In a previous report on resistance in tobacco to the root rot organism, *Thielavia basicola* Zopf., it was noted that the White Burley variety was very susceptible, and the Little Dutch variety very resistant to this disease. Further trial with these and a number of other varieties in Wisconsin and Ontario, Canada, during the last two years has shown that the standard varieties of tobacco as grown in the United States and Canada vary greatly in their degrees of resistance to this disease. To the most susceptible varieties may be added principally the Oronoco and Maryland groups of varieties and the Pennsylvania Broadleaf type. The Connecticut Broadleaf variety and a number of the coarser types of tobacco locally known as Big Seed or Hybrid tobacco are as a rule, very resistant to disease. The Cuban and Havana Seed groups possess an intermediate degree of resistance. It is important that resistant strains be developed within each of these susceptible and semi-resistant groups, as no other satisfactory means for the control of the disease appears to be at hand. The loss due to this disease of tobacco in the United States during the season of 1915 is conservatively estimated at from ten to twenty millions of dollars. Very encouraging results have been secured in selecting for resistance within the White Burley variety. Strains have been secured which yielded in some instances more than one hundred times as much as ordinary White Burley on diseased soil. The quality of these resistant strains of Burley is to all appearances satisfactory from a commercial point of view. Selection for resistance within cigar binder types, i.e., Havana Seed, has yielded less favorable results owing to the difficulty of combining the desired quality with resistance.

Septoria on barley. A. G. JOHNSON

While making observations on certain other barley diseases during the past two seasons, the writer has noted a Septoria on a number of varieties of barley at various points as follows: Brookings, Bruce, Highmore, and Aberdeen, South Dakota, Fargo and Williston, North Dakota, and Hayfield and St. Paul, Minnesota.

The attack of the fungus is chiefly on the leaf-blades; less commonly on the sheaths. The invaded tissues are killed. The attacked portions become yellowish to yellowish brown and vary in size and form from small, narrowly oblong areas, more or less limited laterally by the veinlets, to blotches of considerable size. These lesions not infrequently become confluent and jointly may involve the entire leaf-blade or sheath, or large portions of them. In the dead tissue of the blotches, scattered pycnidia are visible, with the naked eye, as minute black dots. The pycnidia are subepidermal and contain numerous slender slightly curved spores of the Septoria type. The fungus is apparently the same as that on wheat, which is widely distributed in this country, and which usually goes under the name *Septoria graminum* Desm. No cross-inoculations have as yet been made.

Further studies of plum wilt. B. B. HIGGINS

In continuation of the work of which a preliminary report was made before the Phytopathological Society at its meeting in Philadelphia, it has been found by inoculations in the greenhouse and in the field that the fungus to which the plum wilt disease was attributed is capable of infecting plums as well as other species of the genus Prunus and of producing typical symptoms of the wilt with final death of the trees. These experiments indicate that the fungus is a general wound parasite of woody plants, but it has not been found occurring normally in any plant outside the genus Prunus.

The fungus is referred to the genus Lasiodiplodia, and is closely related to *L. theobromae* and to *Diplodia natalensis;* but until a comparative study of these related forms can be made, it seems best to consider this organism as a new species.

Gummosis with special reference to plum wilt. B. B. HIGGINS

To the formation of gum in wood infected with the plum wilt organism is attributed two of the most striking phenomena connected with the plum wilt disease, that is the sudden wilting of the leaves on apparently healthy trees—presumably due to the sudden decrease of the water supply by deposits of gum in the conducting tissue—and the limiting of infection areas in young trees by gum deposit in the surrounding tissue.

The elementary cause of gum formation is rather obscure and has led to much and very divergent speculation. A considerable literature on gummosis in Prunus and other genera in which it occurs has accumulated during the last few years, some writers attributing the phenomenon to enzymatic activity and others asserting that it can not be attributed to this cause.

Notable among the recent contributions on this subject have been those of Sorauer and of Beijerinck. Sorauer, after much experimental production of gummosis, attributes it to excess of hydrolizing over coagulating enzyme, which excess prevents deposition of pectin as formed in the young growing tissue. Beijerinck says that it is a necrobiotic phenomenon produced by an enzyme set free when cells are killed by wounding or by parasitic organisms.

That gum formation is due to enzymatic activity there can be little doubt at present; but from published accounts of experiments of others and from personal observations, it seems necessary to assume that the enzyme forming zymogen is present in all living cells of the plants and breaks down, setting free the enzyme, whenever it comes in contact with certain chemicals, poisons produced by parasites in the tissue, or other stimulating conditions.

Arsenate of lead as a fungicide for apple scab. W. J. MORSE

In a series of apple spraying experiments covering four successive seasons, using the Ben Davis variety, very satisfactory results have been obtained with four pounds of paste or two pounds of dry lead arsenate alone in fifty gallons of water, when compared with lime-sulphur, bordeaux mixture and other fungicidal sprays. With one exception it has controlled scab on the fruit as well or better than did lime-sulphur combined with one pound of the insecticide to fifty gallons. Arsenate of lead produced little or no russeting of the fruit. With it the percentage of merchantable fruit always equaled, and three seasons out of four exceeded, by from 12 to 18 per cent, that obtained with lime-sulphur.

Laboratory experiments by Mr. M. Shapovalov failed to show for arsenate of lead such high fungicidal properties as the field experiments indicated. Germination of conidia of the fungus (*Venturia inaequalis*), placed in similar dilutions of the poison was reduced and retarded, but by no means prevented. Likewise adding arsenate of lead to culture media retarded but did not prevent entirely the growth of the fungus.

Seed and soil disinfectants for the Rhizoctonia disease of potatoes. W. J. MORSE AND M. SHAPOVALOV

These experiments, covering the work of two seasons, are the result of an opportunity offered by a combination of favorable soil conditions and a variety of pota-

toes particularly susceptible to attacks of Rhizoctonia. The seed tubers used bore numerous sclerotia of the fungus and came from plants which were badly injured by the disease for two successive seasons. The first year the plots were located on pasture land which probably had never grown a cultivated crop, the second on land which had been in grass for several years. Only chemical fertilizers were applied.

The results were essentially the same both seasons. Seed tuber treatment with corrosive sublimate was the most successful, but even this was far from efficient. Formaldehyde also materially increased the proportion of healthy plants as compared with the check. On the other hand, sulphur aggravated the disease. Sulphur in the row at the rate of 500 pounds per acre led to an increase of from 20 to 30 per cent of diseased plants.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

October to November, 1915

Allard, Harry Ardell. Distribution of the virus of the mosaic disease in capsules, filaments, anthers, and pistils of affected tobacco plants. Jour. Agr. Research **5**, no. 6: 251–256, pl. 23. November 8, 1915.

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[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Carpenter, Clarence Willard. Some potato tuber-rots caused by species of Fusarium. Jour. Agr. Research **5**, no. 5: 183–210, pl. A-B (col.), 14–19. November 1, 1915.

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[PHYTOPATHOLOGY, for December, 1915 (**6**: 297–356, Pls. XIV–XVII), was issued December 3, 1915.]